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DYNAMICS OF LEAF AREA AND YIELD OF ZUCCHINI PLANTS IN THE FOREST-STEPPE OF THE RIGHT BANK OF UKRAINE

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Abstract

The influence of mulching materials and water-retaining granules on the formation of the assimilation surface and the overall yield of zucchini plants was studied. The leaf surface area depended on the type of mulching material and varied depending on the studied variety. In the initial phases of growth and development of zucchini plants, a slight increase in the vegetative mass of plants was observed. The greatest effect was observed with the use of mulching material of agrofiber black and polyethylene perforated black film, where the increase relative to control was: in the variety Zolotinka – 4.3 and 8.2 cm^2 / plant, in the variety Chaklun – 4.3 and 6.6 cm^2 / plant in accordance.

Gradually, by the end of the growing season in zucchini plants, a decrease in leaf area was observed in all variants of the experiment. However, the best leaf area was preserved with the use of black agrofiber and perforated black polyethylene film. Given the dependence of yield and leaf area, the preserved leaf surface area contributed to the formation of zucchini fruits.

Studies on the area of leaves depending on the variety and mulching material with the use of water-retaining granules Akvod showed a positive effect of the studied factors. Thus, in the phase of three true leaves, the increase in assimilation area using water-retaining granules relative to the option without granules was 0.1 – 0.9 cm^2 / plant, in the flowering phase it was 0.2 – 0.4 thousand m^2 / ha, in the technical phase maturity – 1.5 – 1.8 thousand m^2 / ha. The largest this figure was observed at the end of the growing season of zucchini plants – 0.4 – 2.1 thousand m^2 / ha.

According to the average data, higher yields were observed for mulching the soil with black agrofiber and perforated black polyethylene film, in the Zolotinka variety – 49.7 and 53.3 t / ha, which is 7.3 and 10.9 t / ha more than the control. In the cultivar Chaklun all the studied variants had significantly higher yields, but it was the highest when mulching the soil with black agrofiber and perforated black polyethylene film – 90.0 and 97.8 t / ha, which is 20.2 and 28.0 t / ha, respectively more compared to control. Comparing the years of research, the most productive year was 2018, where the yield, depending on the variant of the experiment, ranged from 50.6 to 105.4 t / ha.

The combined use of Aquod water-retaining granules and mulching the soil provides a higher level of zucchini yield, compared to using only mulching materials. It was found that against the background of the introduction of Aquod granules, all the studied options provided a significantly higher yield of zucchini. The largest increase in yield relative to control was provided by options for mulching the soil with black agrofiber and perforated

black polyethylene film, the yield of marketable products increased by 12.3-21.9 t / ha for the variety Zolotinka and by 26.1-35.0 t / ha for the variety Chaklun.

Keywords: mulching material, water-retaining granules, variety, leaf area, yield.

Introduction. During the growing season the leaf surface area, its photosynthetic activity does not remain constant and is determined by the age of the plant. The main organ of photosynthesis of all green plants is the leaf. Accordingly, the highest and best quality crops can be obtained only in crops that have the optimal size of the leaves and the optimal course of its formation, which will be provided by the most favorable growing conditions. Energy useful substances accumulate in fruits, but their formation occurs mainly in the leaves due to photosynthesis, as the main source of biomass formation [1, 8, 11]. Therefore, the leaf surface area is a valuable agricultural indicator that allows you to plan future harvests, determine the state of plant development at the time of accounting [6, 13, 16].

Providing plants with moisture throughout the growing season makes it possible to obtain higher yields with excellent quality indicators. To achieve this, you need to use mulching materials of synthetic and organic origin, as well as water-retaining granules that are able to retain moisture. Therefore, the study of leaf area and yield of zucchini by mulching the soil and the use of water-retaining granules is relevant [5, 10].

Zucchini fruits significantly complement the range of early vegetables, which are available in limited quantities. They are an excellent raw material for the food and canning industries. Young fruits are eaten (7-12 days), when the seeds are still in their infancy and the pulp is tender. At this time, they contain 7 % dry matter, 5 % carbohydrates, 0.6 % protein, 15-40 mg % vitamin C. Due to the presence of vitamins, easily digestible carbohydrates, pectin, mineral salts, fruits are valuable for the body, have medicinal properties. They are recommended for obesity, hypertension, diabetes, kidney disease, liver [5, 7].

Zucchini (*Cucurbita pepo var. Giraumontia Duch*) is an annual fruit herbaceous plant of the Pumpkin family. Is a variety of hard-boiled pumpkin. This is a plant with a well-developed root system. The central root penetrates into the soil up to 1.5 – 1.7 m, but the bulk of the roots is in the soil at a depth of 40 cm. They play a major role in providing plants with water and nutrients [7, 9].

One of the effective methods of preserving moisture is mulching (translated from the English word mulch - manure or straw). Mulching is the coating of the top layer of soil with a material to improve its properties. This method of agricultural technology is used in different climatic zones, in countries located in the north, mulching plants raises the soil temperature to the appropriate level, and in countries with high temperatures, protects against high temperatures [1, 8].

Mulching the soil with plastic wrap can have a positive effect on plant development and growth, as it is one of the effective agronomic measures in the field to influence a set of factors that increase plant yields [8, 12, 13].

Polyethylene film is used to increase yields and improve the quality characteristics of popular food crops both in the field and in protected soil. In many countries that specialize in growing vegetables, including zucchini, large areas are occupied by crops under the film.

A number of authors confirm that mulching the soil increases the yield of different crops by retaining moisture in the upper soil layer, improves the temperature in the upper soil layer and in the ground air, reduces weeds, the top layer of soil remains loose. There is no need to use herbicides when using soil mulching [10, 16].

According to foreign experience, when the soil was mulched with a black film, there was an acceleration of plant growth, an increase in early yields to 40 %, reducing fruit damage and improving their quality. According to scientists, the black film does not transmit sunlight and counteracts the overheating of the topsoil. Therefore, black film can be used in the south [14, 15].

The black film counteracts the germination of weeds, provides the necessary warming of the soil, raises moisture in the soil, in particular in the upper layer. This film is very sensitive to changes in weather and ambient temperature. According to research by scientists, soil mulching increases the yield of various crops, including early harvest by accelerating the growth and development of plants [7, 9].

Lack of soil moisture causes plant oppression. Irrigation during the growing season optimizes the water regime of plants, but not all the water entering the soil is available to plants. Much of it evaporates and seeps into the soil layer, inaccessible to the root system of plants. To prevent water loss, absorbents – hydrogels are added to the soil [15].

Hydrogels are granules of a special polymer (polyacrylamide) capable of absorbing water and water-dissolved fertilizers, which are hundreds of times the own weight of the granules, and then give them to plants as needed. The granules are able to absorb and, swelling, hold up to two liters of distilled water per 10 g of hydrogel. Adding hydrogel to the soil significantly improves the supply of plants with the required amount of water and nutrients, if they have been added to the water. The hydrogel supplies the plants with water only when their root hairs germinate into swollen granules. It is by germinating in the gel that the roots of the plants can use the moisture and nutrients accumulated in the granules. The roots of plants germinate in swollen hydrogel granules usually within 1.5–2 weeks [4].

Thus, the advantages of the hydrogel are that the hydrogel regulates the degree of humidity. Thanks to it, the soil maintains a relatively constant level of moisture. Thanks to granules the structure of soil improves. Clay substrate becomes less dense, and sandy - less crumbly. The hydrogel has a long service life, which is calculated over several years, or rather at least three years. The granules do not require constant replacement. The crystals are made of environmentally friendly inert material that has a neutral reaction. Therefore, in the process of use there is no acidification of the substrate. The use of "water crystals" saves mineral fertilizers. The liquid fraction of fertilizer can also be absorbed by the granules and gradually (as needed) go into a state accessible to the roots. Biologically important compounds are not washed out of the soil and due to optimal humidity are better absorbed by plants. The hydrogel is absolutely non-toxic to plants, microorganisms, animals and humans. After application of

granules it is possible to apply usual agrotechnical receptions on soil processing. The hydrogel can be used alone (without soil substrate). This allows you to grow plants on hydroponics. For this purpose, many companies now produce colored granules, which look spectacular in glass pots and are the decor of the room. Seeds can be germinated under moisture-absorbing crystals [4].

The purpose of research. Study of the dynamics of leaf area and yield of zucchini plants depending on the type of mulching material and the use of water-retaining granules.

Methods. Work on studying the dynamics of leaf area and yield of zucchini plants depending on the type of mulching material and the use of water-retaining granules was carried out in 2016–2018 in the Right Bank Forest-Steppe of Ukraine in the research field of Vinnytsia National Agrarian University. Gray forest soil, medium loamy with the following indicators: humus content 2.4 %, reaction of soil solution pHkcl 5.8, the amount of absorbed bases 15.3 mg / 100 g of soil, P_2O_5 – 21.2 mg / 100 g of soil, K_2O – 9.2 mg / 100 g of soil.

In the experiments, the varieties of zucchini Zolotinka and Chaklun were studied, against the background of water-retaining granules of aqueduct hydrogel and without the background of granules. The experiment also studied soil mulching with perforated black polyethylene film, black agrofiber, straw and sawdust. Zolotinka and Chaklun without mulch served as control. Plants were sown according to the scheme of 120x70 cm (11.9 thousand pieces / ha). The experiment was repeated four times, the area of the accounting area was 40 m^2. According to the method, phenological observations, biometric measurements and records were performed [2]. Water-retaining granules of aqueduct hydrogel were added to the pre-sowing cultivation at a rate of 20 kg / ha. Before sowing zucchini, the soil was leveled and covered with mulching materials of synthetic origin (perforated black polyethylene film, black agrofiber) in strips 100 cm wide. The edges of mulching materials along the rows were placed in pre-cut furrows and sprinkled with soil cross-shaped incisions in the mulching material for sowing zucchini seeds. Mulching materials of organic origin - sawdust and straw, covered the soil after germination. Harvesting was carried out as the fruit was formed in accordance with the requirements of the current standard - "Fresh zucchini – DSTU 318 – 91" [3]. Statistical data processing was performed using computer programs.

Results and discussion. The leaf surface area depended on the type of mulching material and varied depending on the studied variety. In the initial phases of growth and development of zucchini plants, a slight increase in the vegetative mass of plants was observed. Thus, the leaf area ranged from 46.9 cm^2 / plant – variety Zolotinka without mulch to 68.0 cm^2 / plant – variety Chaklun using as mulching material polyethylene perforated black film (Table 1). The greatest effect was observed with the use of mulching material of agrofiber black and polyethylene perforated black film, where the increase relative to control was: in the variety Zolotinka – 4.3 and 8.2 cm^2 / plant, in the variety Chaklun – 4.3 and 6.6 cm^2 / plant in accordance. Mulching materials of synthetic origin are able to retain moisture in the soil, while creating more favorable conditions for the growth and development of zucchini plants. During the flowering phase and until the end of the vegetation period, a larger area of leaves was observed for mulching the soil with black agrofiber and perforated black polyethylene film relative to the control and other studied variants.

Gradually, by the end of the growing season in zucchini plants, a decrease in leaf area was observed in all variants of the experiment. However, the best leaf area was preserved with the use of black agrofiber and perforated black polyethylene film. Given the dependence of yield and leaf area, the preserved leaf surface area contributed to the formation of zucchini fruits. A strong direct correlation between yield and assimilation surface area in the phase of three true leaves ($r = 0.95 \pm 0.11$), flowering ($r = 0.98 \pm 0.07$), technical maturity ($r = 1.0 \pm 0.02$) and at the end of the growing season of plants ($r = 0.94 \pm 0.10$).

1. Dynamics of growth of leaf surface area in zucchini plants depending on the variety and mulching of the soil (average for 2016–2018)

Version		Three real ones leaf, cm^2 / plant	Flowering, thousand m^2 / ha	Technical maturity, thousand m^2 / ha	The end of the growing season, thousand m^2 / ha
variety	mulching material				
Zolotynka	black agro fibre	51,2	6,8	14,5	7,9
	black perforated polyethylene film	55,1	7,1	17,4	9,1
	straw	47,4	6,3	9,8	6,3
	sawdust	49,4	6,6	12,4	6,8
	without mulch (control)	46,9	6,1	10,5	5,8
Chaklun	black agro fibre	65,7	8,2	12,5	11,6
	black perforated polyethylene film	68,0	8,5	14,6	12,1
	straw	62,4	7,6	11,8	10,7
	sawdust	65,0	7,9	12,5	11,0
	without mulch (control)	61,4	7,4	10,8	10,5

2. Dynamics of growth of leaf surface area in zucchini plants depending on the variety and mulching of the soil with the use of water-retaining granules Akvod (average for 2016–2018)

Version		Three real ones leaf, cm^2 / plant	Flowering, thousand m^2 / ha	Technical maturity, thousand m^2 / ha	The end of the growing season, thousand m^2 / ha
variety	mulching material				
Zolotynka	black agro fibre	52,1	7,1	16,0	9,3
	black perforated polyethylene film	55,2	7,5	19,2	10,9
	straw	47,8	6,5	11,3	6,7
	sawdust	49,8	6,8	14,0	8,5
	without mulch (control)	47,5	6,4	12,0	6,3
Chaklun	black agro fibre	65,9	8,5	14,3	13,7
	black perforated polyethylene film	68,3	8,9	16,4	14,1
	straw	63,3	7,8	13,3	12,4
	sawdust	65,5	8,1	14,0	12,8
	without mulch (control)	62,1	7,6	12,5	11,9

Studies on the area of leaves depending on the variety and mulching material with the use of water-retaining granules Akvod showed a positive effect of the studied factors (Table 2). Thus, in the phase of three true leaves, the increase in assimilation area using water-retaining granules relative to the option without granules was 0.1 – 0.9 cm^2 / plant, in the flowering phase it was 0.2 – 0.4 thousand m^2 / ha, in the technical phase maturity – 1.5 – 1.8 thousand m^2 / ha. The largest this figure was observed at the end of the growing season of zucchini plants – 0.4 – 2.1 thousand m^2 / ha.

According to the average data, higher yield was observed for mulching the soil with black agrofiber and perforated black polyethylene film, in the variety Zolotinka – 49.7 and 53.3 t / ha, which is 7.3 and 10.9 t / ha more than the control (table 3).

3. Commodity yield of zucchini depending on the variety and mulching material

Version			Yield capacity, t/ha				± before control
variety	mulching material		2016	2017	2018	average	
Zolotynka	black agro fibre		47,5	45,2	56,4	49,7	+7,3
	black perforated polyethylene film		57,3	46,6	56,0	53,3	+10,9
	straw		42,3	41,4	52,7	45,5	+3,1
	sawdust		53,0	38,9	51,6	47,8	+5,4
	without mulch (control)		36,5	40,2	50,6	42,4	0,0
Chaklun	black agro fibre		84,7	88,6	96,7	90,0	+20,2
	black perforated polyethylene film		88,4	99,5	105,4	97,8	+28,0
	straw		66,0	77,2	81,7	75,0	+5,2
	sawdust		81,1	84,5	87,0	84,2	+14,4
	without mulch (control)		60,9	70,4	78,2	69,8	0,0
HIP_{05}		A	0,4	0,7	0,6	–	
		B	0,6	1,1	0,9		
		AB	0,9	1,6	1,2		

In the cultivar Chaklun all the studied variants had significantly higher yields, but it was the highest when mulching the soil with black agrofiber and perforated black polyethylene film – 90.0 and 97.8 t / ha, which is 20.2 and 28.0 t / ha, respectively more compared to control. Comparing the years of research, the most productive year was 2018, where the yield, depending on the variant of the experiment, ranged from 50.6 to 105.4 t / ha.

It was found that the factor "variety" on the yield of zucchini affected by 82.0 %, the factor "mulching material" – by 15.0 %, the interaction of factors was not significant – 3 %.

The combined use of water-retaining Aquod granules and mulching the soil provides a higher yield of zucchini, compared to using only mulching materials. It was found that against the background of the introduction of Akvod granules, all the studied options provided a significantly higher yield of zucchini (Table 4).

4. Commodity yield of zucchini depending on the variety, mulching material and water–retaining granules

Version			Yield capacity, t/ha				± before control
variety	mulching material		2016	2017	2018	average	
Zolotynka	black agro fibre		60,6	58,3	69,5	62,8	+12,3
	black perforated polyethylene film		76,4	65,7	75,1	72,4	+21,9
	straw		51,4	50,5	61,8	54,6	+4,1
	sawdust		68,1	54,0	66,7	63,0	+12,5
	without mulch (control)		44,6	48,3	58,7	50,5	0
Chaklun	black agro fibre		100,8	104,7	112,8	106,1	+26,1
	black perforated polyethylene film		105,5	116,6	122,5	115,0	+35,0
	straw		78,1	89,3	93,8	87,1	+7,1
	sawdust		96,2	99,6	102,1	99,3	+19,3
	without mulch (control)		71,0	80,5	88,3	80,0	0
HIP_{05}		A	1,0	0,9	1,0		
		B	1,6	1,5	1,5		
		AB	2,2	2,1	2,2		

The largest increase in yield relative to control was provided by options for mulching the soil with black agrofiber and perforated black polyethylene film, the yield of marketable products increased by 12.3–21.9 t / ha for the variety Zolotinka and by 26.1–35.0 t / ha for the variety Sorcerer. It was found that the factor "variety" influenced the yield – by 74.3 %, the factor "mulching material" – 21.0 %, the interaction of factors – 2.3 %.

The number of fruits in all studied variants was significantly higher relative to control (Table 5). The largest number of fruits is provided by mulching the soil with a perforated black polyethylene film (20.6–31.9 pieces / plant). In the same variant, the largest weight of the fruit was obtained, the increase of which relative to the control was 29 g in the Zolotinka variety and 28 g in the Chaklun variety. A strong (almost linear) direct relationship between yield and number of fruits ($r = 0.99 \pm 0.04$).

5. Biometric indicators of zucchini depending on the variety, mulching material and water-retaining granules

Version		Number of fruit, p/plant	Weight of fruit, g	Fruit diameter, cm
variety	mulching material			
Zolotynka	black agro fibre	18,5	313	5,2
	black perforated polyethylene film	20,6	322	5,2
	straw	17,1	300	5,0
	sawdust	19,1	307	5,0
	without mulch (control)	16,2	293	4,9
Chaklun	black agro fibre	30,8	310	5,1
	black perforated polyethylene film	31,9	322	5,3
	straw	26,2	303	5,1
	sawdust	29,3	308	5,1
	without mulch (control)	24,9	294	5,1

Conclusions and prospects for further research. To obtain a high yield with excellent quality indicators, it is best to mulch the soil with perforated black polyethylene film, which provides yields of 53.3 and 97.8 t / ha, the area of leaves in the phase of technical maturity is 17.4 and 14.6 thousand m^2 / ha. The combination of mulching the soil with the introduction of water-retaining granules in the pre-sowing cultivation makes it possible to obtain a commodity yield of zucchini at the level of 72.4 and 115.0 t / ha, which is 21.9 and 35.0 t / ha more than in the control. The use of water-retaining granules has a positive effect on the formation of the assimilation surface of zucchini plants. Thus, when combining water-retaining granules with mulching the soil with polyethylene perforated black film, the increase in leaf area in the phase of technical maturity is 1.8 and 2.0 thousand m^2 / ha.

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