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ORIGINAL ARTICLE

Effectiveness of the application of soil milling in the growing of the squash (*Cucurbita pepo* var. giraumontia) in the right-bank forest steppe of Ukraine

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The results of research on the use of soil mulching with polyethylene black perforated film, straw and sawdust for growing a squash in the conditions of the Right Bank Forest-Steppe of Ukraine are presented. The effectiveness of mulching of soil is established.

The shortest between phase periods was characterized by the use of mulching of soil with a film of polyethylene black. The shortest between phase periods was characterized by the use of mulching of soil with a film of polyethylene black.

According to the conducted research, the positive influence of mulch materials on the growth, development and fruiting of squash plants has been established. Previously, the phenological phases were marked by multicolored soil with a polyethylene film, and mulching of the ground with sawdust and straw extended the phases of the development of the zucchan in relation to control. It was established that mulching of the soil on the yield of squash affected an average of 85.5%. The analysis has established a strong direct relationship between yield and quantity, as well as the weight of the fetus.

Keywords: Squash; varieties; polyethylene film; black perforated; straw; sawdust; yield

Introduction

In recent years, in the zone of unstable moisture, which includes the Right Bank Forest-steppe of Ukraine, the conservation and rational use of moisture throughout the period of vegetation is important. Therefore, it is expedient to use such an agrotechnical measure as mulching of soil. Mulching is a coating of soil with organic or synthetic material: straw, sawdust, agrofibrous black, polyethylene black perforated film, which provides moisture preservation, improvement of the thermal regime of the superficial layer of air and the upper layer of soil, and decreases the perturbation of crops (Kurpenko et al., 2010).

Weeds compete for moisture and nutrients with cultivated plants, shading plants. The number of weeds can be controlled by manual propagation, mechanized cultivation and mulching. As a rule the combination of all three measures is used in production. According to Shoromotina, organic and synthetic mulching materials have a positive effect on the agrophysical properties of the soil (Soromotina, 2012).

Using a layer of organic mulch materials around plants helps to keep soil moisture and reduces the frequency of irrigation, prevents the growth of weeds that compete with vegetable plants for water and nutrients. As an organic mulch, you can use leaves, lawns without pesticides, fresh sawdust, wood shavings, needles, compost, hay and chopped straw. However, due to a mulch layer, sufficient water should move to the root zone of plants. For example, leaves can form an impenetrable layer. The ideal mulching material is light and sufficiently permeable for passage of water and air (Hessayon, 1999).

Organic mulching materials are especially desirable, as they can be plowed in the fall or next spring and enrich the soil with organic matter. Organic mulching materials are best applied after the soil warms well or after heavy rain. Straw, old hay, grass, leaves, wood chips, sawdust and newspapers are common organic mulching materials. The mulch layer should be thick enough (for example, from 7.6 to 15.3 cm for straw) to prevent weed growth from beginning to end of vegetation (MOFGA's Technical Bulletin Series Bulletin, 2009).

Synthetic mulching materials are used to regulate the growth conditions of vegetable crops. One of the most common synthetic materials that provides a positive effect when growing plants is a polyethylene film black. The main positive effect of the film is the increase in soil temperature, which is positive for plants. When growing plants on the film there is an improvement in the quality of the fruits, reducing the number of weeds, reducing the evaporation of moisture, reducing the weathering of fertilizers and reducing the consolidation of soil (Brown, 2001; Lamont, 1996).

Due to the mulching of the soil with a polyethylene film, favorable conditions are created for the growth and development of plants, which ensures high (Brown, 2001; Ibarra-Jimenez, 1999) and early yields in comparison with open soil, as well as

product quality improvement. In comparison with the open, the polyethylene film black, reduces the amount of light entering the surface of the soil, which helps to limit germination and prevent the growth of weeds (Ngouajio, 2005; Rahman, 1999).

Synthetic mulching materials help maintain soil moisture to improve the growth and development of plants. One of the main reasons for using a film of polyethylene black as a mulching material is the ability to maintain soil moisture. Polyethylene black mulching allows you to save 40% of water (Orzolek, 1993). According to researchers, improving the quality of the fruits is another advantage of mulching the soil film. The quality of the fruits is their purity, taste, damage by pests. The use of a mulch reduces damage by pests (Benoit, 2000).

For mulching of soil, different colors of polyethylene film are used, namely: red, yellow, gray, blue, black and silver and white. According to Stapleton and Duncan, all types of polyethylene films provide significantly higher yields than open soil (Stapleton, 1994). Studies have found that much larger squash crops can be obtained by growing it on a reflective mulch (Stapleton, 2002).

Synthetic mulching materials can warm or cool the soil, help maintain moisture, control weeds, and even repel insects, depending on their color. Transparent synthetic mulching material warms the soil most effectively and used in the beginning of spring to warm it for sowing.

Black and dark green synthetic film is the most effective means of combating weeds. The dark green film transmits more solar heat to the soil than the black, which effectively shades the soil, especially if the soil below it is not in perfect contact with the mulch material. The red polyethylene film is intermediate for heating the soil and allows some weeds to grow (especially grass). However, red polyethylene film can increase the binding of tomatoes due to the reflection of infrared sunlight. Green or dark green films are most effective for the growth of melon fruits.

The white polyethylene film cools the soil (good for cold-resistant crops) and can scare off some insects. Synthetic mulching materials do not allow water to pass through them, so you can use fiber that allows water to penetrate inside. The main disadvantage of synthetic mulching materials is that it decomposes later. Now there are some biodegradable mulching materials on the market and later they can become more widely available (Vegetable Gardening Revised South Dakota State Unversity, 2005).

Black film prevents the growth of weeds, moisture storage and soil warming (Kurpenko, 2010). However, it does not decompose and therefore it needs to be removed in the fall. The black film helps to better heat the soil, which in turn increases the productivity of heat-loving crops such as melon, peppers, eggplants and tomatoes. Black mulching film is easier to install before planting. The film belongs to non-renewable resources and is a source of environmental pollution. To date, biodegradable synthetic mulch materials from corn starch have been developed but they are not approved for use in the industrial production of organic vegetables (Khloptseva, 1997, MOFGA's Technical Bulletin Series Bulletin, 2009).

The purpose of the research is to study the effectiveness of soil mulching on the growth, development and yield of squash plants under the conditions of the Right Bank Forest-steppe of Ukraine.

Materials and methods of research

Work on the study of the formation of a crop for mulching of the soil during the cultivation of a squash was carried out in 2015-2016 in the Right-bank Forest-steppe of Ukraine on the research field of the Vinnytsia National Agrarian University. The soil is gray forest, medium loam with the following parameters: humus content 2.4%, soil solution pHCl 5.8, amount of collected bases 15.3 mg/100 g soil, P_2O_5-21,2 mg/100 g soil, K_2O-9.2 mg/100 g of soil.

The research was conducted with Zolotinka squash variety. In the experiment, multicolored soil was studied with polyethylene black, straw and sawdust. For control, served as an option without mulch. Plants were sown according to the scheme of 120 × 70 cm (11.9 thousand pieces / ha). The repetition of the experiment is four-fold, the area of the registration area is 40 m^2. According to the method, phenological observations, biometric measurements and records were performed (Bondarenko, 2001). Before sowing the courgettes, the soil was straightened and covered with mulching materials of synthetic origin (black polyethylene film perforated) with strips of 100 cm wide. Mulching materials of organic origin-sawdust and straw, the soil was covered after the stairs. Harvesting was carried out as the fruit was formed (DST of Ukraine, 2010). Statistical processing of data was carried out using computer programs.

Results and discussion

The duration of the interphase periods was influenced by the agroactive mulching of the soil. Thus, the shorter period of the ladder - the beginning of the formation of the fruit was for mulching the soil with a film of polyethylene black - 29 days, the duration of which is 8 days less compared with the option without mulch (Table 1).

Table 1. Duration of interphase periods in Zolotinka variety squash plants depending on mulching material (average for 2015-2016).

Mulching materials	Stairs - early formation of the fetus	The beginning of fetal formation - technical stiffness	Duration of fruiting
Without mulch (control)	37	4	82
The polyethylene film is perforated	29	4	92
Straw	38	5	77

Sawdust	35	5	81

The period of the beginning of fetal formation - the technical rudeness did not differ significantly between the studied variants, however, it was shorter than mulching the soil with a film of polyethylene black perforated and on control and was respectively 4 days. One of the most important indicators that affects the size of the harvest is the duration of fruiting. The longest period of fruiting lasted for varieties of mulching of soil with polyethylene black perforated film - 92 days, and at control of 82 days, which is shorter by 10 days. Mulching of soil with straw and sawdust was not caused by a significant reduction in the fruiting duration of the relatively better option and control and was respectively 77 and 81 days. The analysis establishes a strong direct relationship between the harvesting time and yield (r=0,83±0,23).
Studies have shown that mulching materials have a positive effect on the biometric indices of squash plants (Table 2).

Table 2. Biometric indices of Zolotinka's squash plants in the phase of three true leaves depending on the mulching material, (average for 2015-2016).

Mulching materials	Stem length, sm	Thickness of the stem,mm	Leaf area, sm^2/plant
Without mulch (control)	13.8	3.2	47.7
The polyethylene film is perforated	16.4	3.5	55.8
Straw	14.5	3.2	48.2
Sawdust	14.8	3.4	50.2

The largest length of the stem in the phase of the three true leaves was characterized by plants for mulching the soil with a film of polyethylene black perforated-16.4 cm, and on the control-13.8 cm, 2.6 cm less. The experiment variants, using as straw and sawdust mulch, also had a larger stem length relative to controls where the increment was 1.0 and 0.7 cm respectively. The smallest indicator was on the control and was 13.8 cm.
The thickness of the stem in all studied variants did not differ significantly and fluctuated within the range of 3.2-3.5 mm, but when applied with a polyethylene black perforated film, this figure was 3.5 mm.
The largest area in the phase of the three true leaves was the plants for mulching the soil with a film of polyethylene black perforated-55.8 cm^2/plant, which is 8.1 cm^2/plant more than the variant where the mulch material was not used. For mulching of ground with sawdust, the area of leaves was 50.2 cm^2/plant, which is more than 2.5 cm^2/plant without mulch. The smallest increase in leaf area relative to control was obtained in the variant for mulching of straw-0.5 cm^2-plant. However, all studied variants had a large area of leaves relative to control. The positive effect of mulch materials on biometric indices of squash plants was observed on all variants of experiment relative to control (Table 3).

Table 3. Biometric indices of Zolotinka's squash plants in the flowering phase depending on the mulching material (average for 2015-2016).

Mulching materials	Stem length, sm	Thickness of the stem, mm	Number of leaves pcs./plant	Leaf area, m^2/plant
Without mulch (control)	58.8	28	18.4	6.1
The polyethylene film is perforated	64.3	30.7	24.6	7.1
Straw	59.3	27.8	18.7	6.3
Sawdust	60.7	28	20.3	6.6

Analyzing biometric indices of squash plants, it is evident that all mulching materials contributed to their increase compared to control. The largest length and thickness of the stem, the number of leaves and their area were noted for mulching the soil with a film of polyethylene black. Thus, the length of the stem when applied to a film of polyethylene black was 64.3 cm, which is 5.5 cm more control. The thickness of the stem and the number of leaves were larger by 2.7 mm and 6.2 pcs./plant relative to the control, respectively.
An important indicator in the estimation of biometric indices of squash plants is the area of leaves. The largest was the multicolored soil with a film of polyethylene black-7.1 thousand m^2/ha, which is 1.0 thousand m^2/ha, respectively, more than control.
The largest area of the leaves was marked by mulching of the soil with a film of polyethylene black-17.5 thousand m^2/ha, which is 6.4 thousand m^2/ha more than control. A larger area of the leaves with regard to control also had variants for mulching of soil with straw and sawdust.
The use of different types of mulching materials contributed to the increase of leaf area relative to control (Table 4).

Table 4. The dynamics of the growth of the area of the leaf surface in squash plants of the Zolotinka variety depending on the mulching material (average for 2015-2016).

Mulching materials	Three real ones leaf,	Flowering, thousand	Technical rudeness, thousand

	cm^2/plant	m^2/ha	m^2/ha
Without mulch (control)	47.7	6.1	11.1
The polyethylene film is perforated	55.8	7.1	17.5
Straw	48.2	6.3	11.9
Sawdust	50.2	6.6	12.2

In all investigated phases of growth and development of squash plants, the largest area of leaves was marked by mulching of soil with a polyethylene black perforated film. Studies have found that its value depended on the type of mulch material. Thus, in the phase of three true leaves, all mulching materials contributed to an increase in the leaf area relative to the mulch variant. The largest increase relative to control provided the option for mulching the soil with a polyethylene black perforated film-8.1 cm^2/plant. The area of leaves for mulching of soil with straw and sawdust was greater than the variant without mulch, but yielded a variant for soil mulching with a polyethylene black perforated film and amounted to 48.2-50.2 cm^2/plant, respectively. The same pattern was noted in the subsequent stages of development of a squash. Analyzing the phases of development, the largest area was the plants in the phase of technical maturation. The increase in the area of leaves in this phase relative to the flowering phase for mulching the soil with a polyethylene black perforated film was 10.4 thousand m^2 / ha, and at the control-by 5 thousand m^2/ha. The increase in leaf area relative to the mulch variant was due to mulching of ground with straw and sawdust-5.6 thousand m^2/ha in both variants. A strong direct correlation between leaf area and yield (r=0.98 ± 0.10) has been established.

The crop value is the main indicator that determines the effect of the mulch material. During the research period, the size of the crop was uneven and depended on the mulch material. In the years of research, more yield was obtained in 2015, due to the optimum conditions for the growth and development of the squash. From the conducted researches it was established that the use of mulch materials contributed to the increase of the crop of squash plants in comparison with the mulch variant (Table 5).

Table 5. Commodity of squash of Zolotinka variety depending on mulching material.

Mulching materials	Yield, t/ha			± to control
	2015 p.	2016 p.	average by years	
Without mulch (control)	45.1	38.6	41.9	0
The polyethylene film is perforated	54.8	49.3	52.1	10.2
Straw	45.5	43.3	44.4	2.6
Sawdust	46.3	45.7	46	4.2
$LSD_{0.05}$	3.5	2.6	-	_

The most optimal conditions for the growth, development and production of squash plants were formed by mulching of the soil with a polyethylene black perforated film-52.1 t/ha, where the gain in relation to control was 10.2 t/ha. A slightly smaller increment relative to the mulching of the soil with the polyethylene film is perforated, but greater in comparison with the control is noted for variants for mulching of soil with straw and sawdust-2.6-4.2 t/ha, respectively.

The significance of this difference is confirmed by the results of the dispersion analysis over the years of research. It was established that mulching of the soil on the yield of squash affected an average of 85.5%.

The multimillionation of soil with a polyethylene black perforated film was characterized by the best biometric parameters (Table 6).

Table 6. Biometric characteristics of Zolotinka's squash production depending on mulch material (average for 2015-2016).

Mulching materials	Number of fruits pcs./plant	Weight of fetus, g	Fetal diameter, sm
Without mulch (control)	13.9	286	4.7
The polyethylene film is perforated	15.3	313	5
Straw	14.1	291	4.8
Sawdust	14.3	303	4.8

The largest number of fruits was obtained by mulching the soil with a polyethylene black perforated film-15.3 pcs./the plant, which is 1.4 pcs./the plant more than control. The least fruits among the variants with the use of mulch was for mulching of ground with straw-14.1 pc./Plant. The analysis revealed a strong direct correlation between yield and number of fruits (r=0.99 ± 0.07). The largest weight of the fetus had the option of mulching the soil with a polyethylene black perforated film-313 g. This variant was also characterized by the largest diameter of the fetus-5.0 cm, which is 0.3 cm more control. The analysis revealed a strong direct correlation between yield and fetal weight (r=0.96 ± 0.11) and a strong direct correlation between fruit yield and fruit diameter (r=0.99 ± 0.07).

Conclusions

Consequently, according to the conducted research, the positive influence of mulch materials on the growth, development and fruiting of squash plants has been established. Previously, the phenological phases were marked by multicolored soil with a polyethylene film, and mulching of the ground with sawdust and straw extended the phases of the development of the zucchan in relation to control. Mulching of the soil also had a positive effect on the yield and biometric performance of the squash, especially the use of a polyethylene black perforated film, which ensured a yield of 54.8 t/ha in 2015 and 49.3 t/ha in 2016.

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