Research Journal of Food and Nutrition
Volume 4, Issue 2, 2020, PP 20-29
ISSN 2637-5583

Biologized Technology of Watermelon Growing with Drop Irrigation

Volodymir Lymar[1*], Anatolii Lymar[1], Ihor Gorbatenko[2]

[1]*The Southern State, Agricultural Research Station, Institute of Water Problems and Land Reclamation, National Academy of Agrarian Sciences of Ukraine, Hola Prystan, Kherson region 73000, Ukraine*
[2]*Mykolayiv National Agrarian University, Mykolayiv 54020, Ukraine*

***Corresponding Author:** Volodymir Lymar, The Southern State, Agricultural Research Station, Institute of Water Problems and Land Reclamation, National Academy of Agrarian Sciences of Ukraine, Hola Prystan, Kherson region 73000, Ukraine*

ABSTRACT

The processes that determine the nutrient status, biological activity of the soil were researched; the potential fertility of the soil in terms of energy stored in the "soil-plant" system using soil cover culture as a transformer of photosynthetic activity of plants (PAP) energy into organic matter was estimated; the best soil culture for binary microstrips watermelon growing (witer rye) was determined, which predominates over other cultures.

Keywords: *watermelon, southern chernozem, drip irrigation, soil fertility, soil cover culture, mineral nutrition, bacterization, yield*

INTRODUCTION

The object of research is watermelon of variety Kniazhych, southern sandy chernozem, growth processes, plant development, crop formation and its quality, changes in agrochemical and agrophysical properties of the soil under the influence of technological methods of cultivation.

The objective of the work is to develop agrotechnical measures to improve the fertility of the southern low-humus sandy chernozem and to improve the technologies of growing watermelon and tomato under drip irrigation.

MATERIALS AND METHODS

Methods used in the research are the following: field – determination of crop, biometric accounting and measurement; laboratory – analysis of fruit quality, content of mineral nutrients in the soil; economical and mathematical – assessment of economic efficiency of the studied elements and technology in general; mathematical and statistical – conducting analysis of variance and statistical processing of experimental results.

RESULTS AND DISCUSSIONS

According to the research results, the best soil cover crop selected is winter rye (*Secale cereale*), which outperforms other crops in terms of:

- actual intake of dry organic matter into the soil, which is 1.6 times more than white mustard (*Sinapis alba*) and 2.7 times more than the sowing peas (*Vicia sativa*);
- the highest biological activity of the soil, which when applied ½ from the recommended dose of fertilizers and the use of Biogran amounted to 94.9 mg $CO_2/m^2 \times h$;
- the lowest density of soil composition before sowing in the 0-10 cm horizon is 1.24 g/cm^3, while in the control it is 1.26 g/cm^3;
- positive effect on the thermal regime of the soil during the period of obtaining watermelon seedlings and planting tomato seedlings; ploughing the soil and mulching between rows with plant mass increases the soil temperature at a depth of 10 cm by 4.2ºC, compared with control;
- watermelon yield, which is 40.6 t/ha, obtained by applying the recommended dose of mineral fertilizers and pre-sowing inoculation of watermelon seeds with Biogran, which is 8.1 t/ha higher than in the control;
- tomato yield, which is 53.3 t/ha, obtained by applying the recommended dose of fertilizer and pre-sowing inoculation of seeds with ABT, which is 3.4 t/ha higher than in the control;
- the indicator of the intensity of energy accumulation in the system "soil-plant" with the help of soil cover culture, as a transformer of PAP energy into organic matter and indicators of economic efficiency.

In the southern region of Ukraine there are favorable natural conditions for growing melons. The optimal ratio of thermal and insolation resources, as well as soils of sandy and bound-sandy granulometric composition, have become the main prerequisite for obtaining high quality melon products. However, it is not always possible to get high yields of watermelon, because in the main area of commercial production, which is almost 75% of the area under crops is concentrated on non-irrigated land, which has insufficient moisture during the growing season. Therefore, the yield of watermelon directly depends on the amount of precipitation, which in recent years is significantly insufficient for the formation of products. As a result, melon producers are paying more and more attention to the irrigation of watermelon, especially drip, the area of which is increasing every year. At the same time, one-sided depletion of the soil with its intensive use, without the return of nutrients and organic matter, leads to the gradual degradation of the soil.

One of the most significant diagnostic signs of soil degradation is a decrease in the content of organic matter and its main component – humus. The primary dependence of the productive potential on the humus content in the soil determines the need for such agronomic measures aimed at reproducing the humus content, namely: increasing the flow of organic compounds into the soil; improving the conditions of humification of plant residues; reduction of soil humus mineralization in the cultivation of crops.

In the south of Ukraine, the annual losses of humus in soils are about 0.6 t/ha and occur due to the predominance of the rate of mineralization of organic matter in the soil over their receipt. Taking into account this indicator, 6–8 tons of manure must be applied annually for each hectare of crop rotation area to reproduce soil fertility. The use of such a quantity of manure in modern agricultural production of Ukraine is impossible. In most areas of the Steppe it is applied only 0.5–0.6 t/ha and, as a consequence of the last 10–15 years, the decrease in humus content is 0.2–0.4%.

According to the data on the study of soils, the concept of reproduction of soil fertility in crisis conditions has developed new technologies and standards for the use of organic fertilizers. Components of the new technology are a system of agronomic measures, which involves reducing the number of row crops in field crop rotations, minimizing tillage, attracting green manure as organic fertilizers, crop residues, as well as increasing the efficiency of manure as fertilizer and humus [1].

Among the measures aimed at ensuring a deficit-free balance of humus, the most important are plant residues and organic fertilizers. An important addition to the humus balance is the entry into the soil of organic matter with roots and post-harvest residues of field crops. The mass of plant residues absolutely increases with increasing yield, but per unit yield it, on the contrary, decreases.

Field crops can be divided into three groups according to the influence on the level of humus condition of the soil: 1) perennial grasses; 2) annual cereals and legumes; 3) annual row crops [2].

Row crops are characterized by higher nutrient removal and more demanding to the level of humus and soil fertility. Losses of humus under row crops are 2 times higher than in crops of continuous sowing.

Measures to increase the flow of organic matter into the soil include: expanding crops of perennial grasses, especially legumes, growing intermediate crops and greens, replacing pure vapors with busy ones.

Humification of organic matter of both manure and plant residues depends on their combination with mineral fertilizers. Co-application of mineral fertilizers (especially nitrogen) together with post-harvest residues and green manures increases the humification rate by 23–25% [3].

When growing melons under drip irrigation, the conditions for the implementation of classical measures aimed at preserving soil fertility are not always created. In particular, difficulties with the use of crop rotation factor, perennial grasses, mainly legumes, straw, reducing the number of row crops, etc. In our opinion, among the measures to increase the flow of organic matter into the soil under the conditions of drip irrigation, the most effective at the present stage should be the use of ground cover crops under the conditions of the microstrip method of growing row crops.

Microstrip Method of Growing Row Crops

Under the conditions of drip irrigation, a microstrip method of watermelon cultivation is a very effective measure to increase soil fertility. According to this method, in broad rows, before sowing the main row crop, in continuous crops, ground cover crops are grown. As ground cover crops can be used sidereal crops adopted in conventional agriculture - annual legumes, crucifers and cereals. Ground cover plants are a source of organic matter, which are fully or partially earned in the soil 10–12 days before sowing the main crop. The importance of ground cover crops is that they create a layer of plant mulch between rows of the main crop, which achieves regulation of phytosanitary conditions, thermal, water and nutrient regime of the soil, improving soil fertility, increasing crop productivity. Of particular importance are the biological features of the soil culture, its ability to quickly accumulate sufficient mass, not to interfere with the growth and development of the main crop, to inhibit the development of weeds.

The peculiarity of the microstrip method of growing watermelon is that in the next year the laying of the drip tape, and with it the location of the rows of sowing of the main crop occurs with a shift towards the row spacing. Thus, this method of cultivation achieves micro-alternation of crops, when the irrigated strip occupied by watermelon returns to its previous place after 4-5 years.

According to scientists [4, 5] it is proved that when placed in between rows of ground cover plants, soil fertility is restored, weed growth is inhibited. Therefore, a very important task of our research was to improve the technology of growing watermelon based on the microstrip method of cultivation.

Green manures are usually sown when the fields are freed from the main crops, and in the south of Ukraine green manures are sown in spring in pure crops and under winter crops. Green manures are grown mainly in pairs (sidereal steam), plowed in the same year. The positive role of green manure is in improving the nitrogen regime of the soil found on the lands of the Kherson Agricultural Institute. When using green manure (pea-oat mixture), the amount of nitrates in saline dark chestnut soil increased 1.5–2 times compared to non-fertilized control. Ploughing green mass of green manures promotes the formation of water-resistant aggregates and improves soil structure. Scientists have proved that the number of water-resistant aggregates in the arable layer of dark chestnut saline soil when plowing green manure at a rate of 21 t/ha increases by 10%, and when plowing manure at a rate of 25 t/ha – by 8%. The effectiveness of green manure depends on the timeliness of sowing. The earlier sowing is carried out, the more green mass accumulates [6].

The term of ploughing greens significantly affects the effectiveness of green manure. Leguminous greens, due to the narrow ratio of K and N, decompose rapidly in the soil. Therefore, they are plowed into the soil shortly before sowing the main crop to prevent nutrient loss.

Today, the importance of rhizosphere microflora in providing crops with essential nutrients has been established, the peculiarities of the relationship between microorganisms and plants have been studied, and microbiologists have established the phenomenon of associative nitrogen fixation. Intensive research in the field of soil microbiology allows us to clarify both the mechanisms of functioning of the system (soil-microorganisms-plant) and applied aspects of the use of beneficial microflora in agricultural production [7, 8].

Numerous field experiments have shown that the effectiveness of preparations on the impact on the production process of plants can be equivalent to 40–60 kg/ha of mineral nitrogen and 15–30 kg/ha of phosphorus. This is due to both the growth of fertilizer absorption rates and the improvement of structural metabolism of plants, in which the mineral compounds of nitrogen and phosphorus in the plant body are directed to the synthesis of organic compounds and accumulate in the plant body. Modern microbial preparations make it possible to reduce the level of use of synthetic agrochemicals and reduce the risk of contamination of plant products and the environment [9].

In 2015, we developed an ecological technology for growing melons on non-irrigated lands which provides increased productivity of watermelon (*Citrúllus lanátus*) and nutmeg pumpkin (also called *Cantaloupe*), preservation and rational use of soil fertility, reducing the agrochemical load on the soil, obtaining high quality products suitable for use in rational and dietary nutrition.

The content of ecological technology is as follows: mineral fertilizers for watermelon and nutmeg pumpkin in the dose of $N_{30}P_{45}K_{30}$ are applied in the spring before the first continuous cultivation locally in the area of the future row by a cultivator-fertilizer equipped with a marker; pre-sowing treatment of melon seeds with microbiological preparations is carried out (watermelon with preparation of combined effect Biogran, and nutmeg pumpkin with preparation of nitrogen-fixing action Azotobacterin). During 2011–2015, research found that inoculation of seeds with microbiological preparations promotes the development of beneficial rhizosphere microflora, improves nutrition, stimulates plant growth and development by mobilizing soil nutrients, inhibits the development of phytopathogenic fungi and bacteria. The effect of biological products is equivalent to 30 kg/ha of mineral nitrogen, 45 kg/ha of phosphorus and 30 kg/ha of potassium [10].

Therefore, for the first time in the south of Ukraine on the southern sandy chernozem we study the use of biologicals based on nitrogen-fixing and phosphorus-mobilizing microorganisms on the background of the recommended and ½ of the recommended dose of mineral fertilizers in melon agrocoenosis under drip irrigation.

Fertilization of Watermelon

Scientists [11] found that the optimal dose of fertilizer for watermelon is $N_{60}P_{90}K_{60}$, which is applied in a continuous manner and is recommended for chernozem sandy soils in southern Ukraine. Further studies of the institution confirmed the norms of the recommended dose of mineral fertilizers for watermelon and the method of their application and proved the effectiveness of the local method of mineral fertilizers in the norms that are 2-3 times lower than the recommended dose [12, 13].

Conditions for Research

The research was conducted in the south of Kherson region, which is located within the Lower Dnieper sand arena of Holoprystan district of Kherson region. Soils are represented by southern solonetsous sandy loam chernozem with a significant thickness of humus profile – up to 76 cm, with humus content up to 1.0%. The reaction of the soil solution is close to neutral. Soils are not saline with easily soluble salts.

The farm is located in the second (southern) agro-climatic region of Kherson region, where climate is hot and very arid. According to long-term data, the average annual air temperature is +9.9°C. The coldest month of the year is January, the average monthly temperature of which is 2. 6°C, July is the warmest month of the year, its average air temperature is 22.8°C. The average annual rainfall is 418 mm. The sum of temperatures above 10°C is 3300–3400°C, the amount of precipitation during this period is 200–220mm. Hydrothermal coefficient (HTC) of the growing season is 0.5. The average duration of the frost-free period is 180–200 days, and the growing season is 225–230 days. High temperature and low humidity cause intense evaporation from the soil surface and transpiration. Evaporation during the warm period of the year (April-October) is 900–1100 mm, which is 3.0–3.5 times higher than the annual rainfall. Daily evaporation is 8–10 mm, or 80–100 m^3/ha, and the maximum daily evaporation can reach 14–15 mm.

The farm is located in the area of incomplete spring soaking. The maximum reserves of productive moisture in a meter layer are observed in the spring and after wet autumn-winter periods and can reach 100–120 mm. In dry years, stocks are only 50–70mm, and the depth of soaking is 40–60cm.

The Scheme of the Research

The research was carried out using watermelon of variety Kniazhych by setting up a field multi-factorial research, where:

Factor A (soil cover culture – green manure): a) without soil cover crop (k); b) cereals (winter rye), c) cruciferous (white mustard), d) legumes (sowing peas).

Factor B (mineral nutrition level): a) recommended dose ($N_{60}P_{90}K_{60}$) control – according to State standards of Ukraine (DSTU) 5045:2008; b) ½ from the recommended dose ($N_{30}P_{45}K_{30}$).

Factor C (inoculation of seeds with a bacterial preparation): a) without inoculation (k); b) ABT; c) **Albobacterin**; d) Biogran.

The area of the elementary plot of the research is 175 m^2. The registered area is 100 m^2. The total area of the research is 1.2 hectares. The research was repeated four times. Row spacing is 350 cm, growing scheme is 350×50 cm (plant feeding area is 1.75 m^2). Pre-irrigation soil moisture in watermelon crops is 75–75–70% HB.

Research Results

According to the working hypothesis, which was put forward by us during the development of the experimental scheme, it is the biomass of the ground cover culture that is of great importance in the technology of watermelon cultivation under drip irrigation. It is assigned the role of a source of organic matter, nitrogen and ash elements, as well as a powerful phytomeliorant. Melons are grown with wide rows of crops, so the introduction into the agrophytocoenosis of intermediate soil cover crops of a continuous method of sowing is of great meliorative value. With their participation there is a regulation of the salt regime, root loosening of the subsoil layer, mulching between rows of watermelon. The entry of organic matter into the soil with plant residues of field crops is a significant addition to the humus balance.

Among ground cover (green) crops, the highest yield of aboveground mass was obtained in the variant with winter rye – on average 19.4 t/ha, while in the variant with white mustard – 13.4 t/ha and sowing peas 7.7 t/ha . A significant addition to the total biomass of plants was their root residues, which, depending on the type of culture, make up from 45 to 60% of the aboveground mass. Thus, the highest yield of total biomass among the studied ground cover plants was obtained in the variant with winter rye – 31.0 t/ha, while in the variant with white mustard – 19.4 t/ha and sowing peas – 11.5 t/ha.

Taking into account the isohumus coefficient*, the largest amount of dry organic matter that entered the soil with aboveground and root residues was provided by winter rye – 3.72 t/ha. In the variant with white mustard, 2.33 t/ha of dry organic matter and 1.38 t/ha of sowing peas actually entered the soil (Table 1).

Table1. *Intake into the soil of organic matter with plant mass of ground cover crops*

Ground cover culture	Average yield of green mass, t / ha	% of roots to the aboveground mass	Received with roots and green mass of ground cover crops, t/ha	Dry organic matter, received with plant mass, t/ha
Winter rye	19,4	60	31,0	3,72
White mustard	13,4	45	19,4	2,33
Sowing peas	7,7	50	11,5	1,38

**According to the generalized norms of humification of organic materials (dry organic matter of plants) the isohumus coefficient for postharvest residues of melons and intermediate green manure crops is 12%.*

Thus, we can state that when using winter rye as a ground cover crop, the actual intake of dry organic matter into the soil is 1.6 times higher than from white mustard and 2.7 times higher than from the use of sowing peas.

The cultivation ploughing of ground cover crops in the experiment influenced the agrophysical properties of the soil. It is proved that the density of the arable soil layer depends on the type of soil cover culture. Before sowing watermelon, the least compacted arable soil layer was in control (without soil cover culture) – 1.28 g/cm^3. In variants with soil cover culture, compaction of the arable soil layer was noted: sowing peas – 1.30 g/cm^3, winter rye – 1.31 g/cm^3 and mustard – 1.35 g/cm^3. However, in the 0–10 cm horizon, the lowest soil composition density was observed in the variant with winter rye – 1.24 g/cm^3, while in the control it is 1.26 g/cm^3.

Studies have shown that growing, ploughing and mulching the soil surface with a green mass of soil cover affects the reserves of productive moisture. Thus, before sowing watermelon, the largest amount of productive moisture in a meter layer of soil was contained in the control (without soil cover culture) on average – 84.4 mm, in variants using mustard, on average – 62.3 mm, sowing peas – 65.7 mm. The lowest moisture reserves were observed in the variant with winter rye – 42.6 mm.

Growing of ground cover crops took place without irrigation, therefore, soil moisture after their ploughing in the soil and in the control was different. It was found that before sowing watermelon reserves of productive moisture in a meter layer of soil of the studied variants ranged from 84.4 mm in control to 42.6–65.7 mm for growing ground cover crops. The smallest reserves of productive moisture in the meter layer were accumulated during the cultivation of rye as a ground cover crop – 42.6 mm.

In the ripening phase of watermelon fruits, the reserves of productive moisture in a meter layer of soil in the variants of the experiment were quite high and ranged from 52.6 mm to 64.3 mm. During the watermelon growing season, the amount of precipitation was 57 mm, which is much less than the average long-term data (119 mm). Given that during the growing season the amount of precipitation and the amount of moisture evaporated from the soil surface in the experiment were the same, the total moisture consumption of watermelon plants depended on irrigation rate, soil cover, mineral nutrition and the use of bacterial preparations for presowing seed inoculation. During the watermelon growing season, depending on the presence or absence of soil cover culture, 20 to 22 irrigations were carried out to maintain soil moisture at the level of 75–75–70%. A lower irrigation rate of 800 m^3/ha at 20 irrigations was recorded in the variant where watermelon was grown without a ground cover crop, a higher one – 880 m^3/ha at 22 irrigations – with the use of ground cover crops.

The highest total moisture consumption was observed in the variants without the use of soil cover culture, which, depending on the level of mineral nutrition and the use of biological products ranged from 1608 to 1688 m^3/ha, while the lowest was in the variants of the experiment with winter rye, where, depending on the level mineral nutrition and the use of biological products, it ranged from 1252 to 1297 m^3/ha. The total moisture consumption in the variants with white mustard and sowing peas was almost the same and depending on the level of mineral nutrition and the use of biological products ranged from 1430 to 1524 m^3/ha.

An important indicator of the efficiency of moisture use by watermelon plants, depending on the studied factors, is the coefficient of water consumption, or the total use of soil moisture for the formation of 1 ton of fruit. Thus, the lowest amount of soil moisture, which was 31.2 m^3 per 1 ton of fruit, was used in the version with winter rye as a ground cover crop, the recommended level of mineral nutrition and pre-sowing inoculation of watermelon seeds with the bacterial preparation Biogran. The average water consumption coefficient in the variants without ground cover crop (control) was 50.2 m^3/t, while with ground cover crops the following were: winter rye – 39.7 m^3/t, sowing peas – 50.3 m^3/t and white mustard – 46.7 m^3/t.

Studies conducted before the experiment (sowing of ground cover crop – winter rye) found that the amount of nitrate nitrogen in the arable soil layer was, on average, 5.6 mg/kg, P_2O_5 – 41.0 mg/kg and K_2O – 220.0 mg/kg of absolutely dry soil. Subsequently, according to the scheme of the experiment, cultivation and ploughing of ground cover crops, application of bacterial preparations and application of mineral fertilizers, which changed the content of nutrients in the soil, were carried out. Thus, in the phase of obtaining watermelon seedlings, the highest content of nitrate nitrogen (at the control level of nutrition and without bacterization of seeds) in the arable layer was contained in the version without soil cover culture –8.6 mg/kg of absolutely dry soil, while with winter rye –7.2 mg/kg, white mustard –7.4 mg/kg and sowing peas – 8.0 mg/kg. The use of bacterial preparations for pre-sowing inoculation of watermelon seeds increased the content of nitrate nitrogen in the soil, compared with the control (without bacterization). Thus, in the variant "without soil cover culture" bacterization of seeds with ABT increased the content of nitrate nitrogen in the soil from 8.6 mg/kg to 9.8 mg/kg, Albobacterin – up to 10.0 mg/kg and Biogran – up to 10.6 mg/kg of absolutely dry soil.

In the variant with winter rye as a ground cover culture, bacterization of seeds with ABT drug increased the content of nitrate nitrogen in the soil from 7.2 mg/kg to 8.0 mg/kg, Albobacterin – up to 7.9 mg/kg and Biogran – up to 8.3 mg/kg of absolutely dry soil. The same pattern with respect to nitrate nitrogen was observed for other soil cover crops.

At the control level of mineral nutrition and without bacterization of seeds in the phase of obtaining watermelon seedlings, the highest content of mobile phosphorus in the arable soil layer was observed in the variant "without soil cover culture" – 49.0 mg/kg of absolutely dry soil, while with winter rye – 44.1 mg/kg, white mustard – 45.1 mg/kg and sowing peas – 48.2 mg/kg. The use of bacterial preparations for pre-sowing inoculation of watermelon seeds helped to increase the content of mobile phosphorus in the soil, compared with the control (without bacterization). Thus, in the variant "without soil cover culture" bacterization of seeds with ABT drug increased the content of P_2O_5 in the soil from 49.0 mg/kg to 55.2 mg/kg, Albobacterin – up to 58.9 mg/kg and Biogran – up to 64.4 mg/kg of absolutely dry soil.

In the variant with winter rye, bacterization of seeds with ABT increased the content of mobile phosphorus in the soil from 44.1 mg/kg to 46.8 mg/kg, Albobacterin – up to 48.4 mg/kg and Biogran – up to 50.1 mg/kg of absolutely dry soil. In variants with other soil cover crops, relative to mobile phosphorus, the same pattern is observed.

In the process of watermelon cultivation there was a gradual intake of nutrients into the soil with mineral fertilizers (fertigation), as well as due to the activity of bacterial preparations and mineralization of plant residues of ground cover crops, which were spent on plant growth and development. Therefore, the difference between the content of nutrients in the soil at the beginning of the watermelon growing season and at the time of fruit ripening was insignificant.

It is known that the main factor that determines the life of the soil are the existing microorganisms in it, which in the process of life, interacting with environmental factors, provide a gradual change in its composition and agronomically useful properties. Metabolism of soil microorganisms is accompanied by the release of a certain amount of carbon dioxide, which is a kind of indicator of biological activity of the soil. The biological activity of the soil in the rhizosphere of watermelon, from its fixation at the beginning of plant vegetation (germination phase) to its gradual extinction (fruit ripening phase), according to the experimental variants was characterized by stable changes. The maximum of biological activity, regardless of the variants of the experiment, was observed in the flowering phase of watermelon plants.

Ploughing soil cover culture helped to increase the biological activity of the soil in watermelon crops, even at the beginning of its cultivation. If the use of bacterial preparations in the cultivation of watermelon without soil cover culture increased the intensity of CO_2 production from the soil in the tent phase, at best, by 9.7%, then with soil cover crop this figure increased by 15.4% (winter rye), 13.7 % (sowing peas) and 15.7% (white mustard). The highest biological activity of the soil in the watermelon tent phase was observed in the variant with winter rye, application of ½ from the recommended dose of fertilizers and application of Biogran – 94.9 mg $CO_2/m^2 \times h$. It should be noted that the same version of the experiment was distinguished by the production of CO_2 from the soil throughout the growing season of watermelon. The peak of biological activity of the soil in all variants of the experiment was observed in the flowering phase of watermelon, in the phase of fruit ripening there was a gradual attenuation of the intensity of "breathing" of the soil.

The total yield of PAP (photosynthetic activity of plants) during the growing season of ground cover crops and watermelon ranged from 7927 GJ/ha in the control (without ground cover crop) to 11651 GJ/ha in the version with winter rye and 9616 GJ/ha in the options with mustard and sowing peas. Determination of the coefficient of use of PAP by watermelon crops depending on the studied factors was carried out in order to assess the potential fertility of the soil in terms of energy intensity in the system "soil-plant" using ground cover culture as a transformer of headlight energy into organic matter. In the reporting year, which was extremely difficult due to weather conditions, the largest amount of solar energy was absorbed by watermelon crops together with winter rye, where the PAR utilization rate was 1.18% at the recommended nutrition level and 1.13% at ½ from the recommended level, while in control (without ground cover culture) – 0.93%. There was also an increase in the use of solar energy in the joint cultivation of watermelon with mustard, where the coefficient of use of PAP was 1.12% at the recommended level of nutrition and 1.09% at ½ from the recommended level. When growing watermelon in the same field with the sowing peas, the utilization rate of PAR was at the level of the control variant (without ground cover culture).

The yield of watermelon was influenced by all the studied factors. Thus, the yield of watermelon in the control version with the recommended level of nutrition ($N_{60}P_{90}K_{60}$) and without sidereal culture and pre-sowing bacterization of seeds was 32.5 t/ha, while at half the recommended dose it was 31.8 t/ha. That is, the application of mineral fertilizers under watermelon in a dose of ½ from the recommended for cultivation without soil cover culture and without bacterization of seeds caused a decrease in yield by only 0.7 t/ha compared to the recommended dose (Table 2).

Table2. *The efficiency of growing watermelon in the experiment*

Ground cover crop	Level of mineral nutrition	Inoculation of seeds with a bacterial preparation	Yield capacity, t/ha	Straight costs, UAH/ha	Conditional net income, UAH/ha	Cost, UAH/t	Profitability, %
Without ground cover crop	$N_{60}P_{90}K_{60}$ control	Without bacterization (к)	32,5	35051	13699	1078	39
		ABT	35,9	35105	18745	978	53
		Albobacterin	36,1	35101	19049	972	54
		Biogran	38,5	35113	22637	912	64
	$N_{30}P_{45}K_{30}$	Without bacterization (к)	31,8	31450	16250	989	52
		ABT	34,9	31504	20846	903	66
		Albobacterin	34,9	31500	20850	903	66
		Biogran	37,5	31512	24738	840	78
Winter rye	$N_{60}P_{90}K_{60}$ control	Without bacterization (к)	32,7	36171	12879	1106	36
		ABT	36,9	36225	19125	982	53
		Albobacterin	34,1	36221	14929	1062	41
		Biogran	40,6	36233	24667	892	68
	$N_{30}P_{45}K_{30}$	Without bacterization (к)	29,7	32570	11980	1097	37
		ABT	33,1	32624	17026	986	52
		Albobacterin	32,3	32620	15830	1010	48
		Biogran	41,4	32632	29468	788	90
HIP05: A – 0,79 t; B - 0,56 t; C – 0,79 t; AB - 1,12 t; AC - 1,59 t; BC - 1,12 t; ABC - 2,25 t							

The efficiency of mineral fertilizers was high in the variants with ground cover crops. For example, when growing watermelon in the variant with winter rye as a ground cover crop and without bacterization of seeds, the application of the recommended dose of mineral fertilizers made it possible to obtain 32.7 t/ha of fruit, while the halved dose was 29.7 t/ha. That is, the application of mineral fertilizers under watermelon at a dose of ½ of the recommended, with the cultivation of winter rye as a ground cover crop and without bacterization of seeds, caused a decrease in yield by 3.0 t/ha compared to the recommended level of mineral nutrition.

An intake of mineral fertilizers under watermelon in a dose of ½ from the recommended one and for growing white mustard and sowing peas as soil cover crops without bacterization of seeds, causes a decrease in yield, respectively, by 2.0 and 0.3 t/ha. When growing watermelon with different soil cover crops at the recommended level of mineral nutrition (control 2) and without seed bacterization (control 3), higher watermelon yield was obtained in the version with winter rye – 32.7 t / ha and mustard – 30.6 t / ha ($HIP_{05}A$ – 0.79 t), while with peas it was 29.6 t/ha. Pre-sowing bacterization of watermelon seeds with the studied preparations had a positive effect on watermelon yields.

The highest yield of watermelon was obtained in the variant with winter rye as a ground cover crop, application of the recommended dose of fertilizers and pre-sowing inoculation of watermelon seeds with the bacterial Biogran preparation was 40.6 t/ha, while in the control version it was 32.5 t/ha.

Thus, the cultivation of winter rye as a ground cover crop in between watermelon rows, its mowing and subsequent partial ploughing into the soil and mulching of its surface with plant mass, sowing watermelon seeds, which were subject to pre-sowing inoculation with bacterial drug Biogran, intake of mineral permits $N_{60}P_{90}K_{60}$ allowed to obtain a watermelon harvest at the level of 40.6 t/ha, which is 8.1 t/ha, or 24.9% more than in the control (without soil cover culture and without seed bacterization).

The chemical composition indicators of watermelon fruits depended more on the level of mineral nutrition and bacterization of seeds than on the ground cover culture. Thus, on average, a greater amount of dry soluble matter and the amount of sugars was contained in the fruits obtained from the variants where watermelon was grown with the application of mineral fertilizers in the recommended dose than in the reduced one.

Inoculation of seeds with bacterial preparations, at appropriate levels of mineral nutrition, also helped to increase the dry soluble matter content in watermelon fruits.

The largest amount of dry soluble matter and the amount of sugars was contained in fruits obtained from the variant where watermelon was grown with winter rye as a ground cover crop, applying the recommended dose of fertilizers and pre-sowing inoculation of watermelon seeds with bacterial preparation Biogran, which were and 9.6% and 8.98% respectively, while the fruits of the control variant were 8.8% and 7.40%. In all variants of the experiment, the amount of nitrates was significantly lower than the MPC (60 mg/kg of pulp).

Even at rather low purchase prices for watermelon fruits (on average 1,500 UAH/t) and significant production costs, a relatively high economic efficiency of growing this crop was obtained. Gross profit directly depends on the yield, which in turn is determined by the influence of the studied elements of watermelon growing technology. The highest gross profit from watermelon cultivation in the experiment was obtained in the variant with winter rye as a ground cover crop, application of the recommended dose of fertilizers and pre-sowing inoculation of seeds with the bacterial preparation Biogran, which amounted to 60900 UAH/ha, which is 12150 UAH/ha more than in the control (without soil cover culture and without seed bacterization). However, for an objective assessment of the economic efficiency of growing crops, the indicator of conditional net profit is more indicative, which takes into account production costs depending on the studied elements of technology. The production costs of watermelon cultivation in the experiment depended on all the studied factors, but mostly on soil cover crops and mineral fertilizers. If in the control variant of mineral nutrition, which is the recommended dose, their cost was 7200 UAH/ha, then in another variant for their intake in a dose of ½ of the recommended one, production costs decreased by 3600 UAH/ha. Another situation with ground cover crops and bacterial preparations, when their inclusion in the technology of watermelon cultivation led to an increase in production costs. And if the operation to bacterize watermelon seeds increased production costs from 50 UAH/ha to 62 UAH/ha, depending on the preparation, then when growing and ploughing ground cover crops, depending on their type, this increase was from 824 UAH/ha to 2260 UAH/ha. It should be noted that in the formation of production costs for growing ground cover crops the cost of sown seeds was determined, which was: 824 UAH/ha for white mustard, 1120 UAH/ha for winter rye and 2260 UAH/ha for the sowing peas.

The highest net profit, which amounted to 25568 UAH/ha and profitability of production was 78%, at the lowest cost of watermelon 840 UAH/t, was obtained with rye as a ground cover crop, intake of the recommended dose of mineral fertilizers and bacterization of seeds with the drug Biogran, while in control, respectively, it was 13699 UAH/ha, 39% and 1078 UAH/t.

Among other variants of the experiment, according to the indicators of economic efficiency, quite high values were observed in the variant without soil cover culture, application of the recommended dose of mineral fertilizers and bacterization of seeds with Biogran, where profitability (78%) and cost of production (840 UAH/t) were better option, but the net profit was 830 UAH/ha less.

Thus, in determining the economic efficiency of watermelon cultivation with the use of ground cover crops, the highest rates were in winter rye, which ploughing into the soil together with pre-sowing bacterization of seeds with Biogran and application of ½ from the recommended dose of mineral fertilizers $N_{30}P_{45}K_{30}$ provided a conditional net profit of 25568 UAH/ha, profitability of production – 78% at the cost of fruits 840 UAH/t.

Conclusions

The processes that determine the nutrient status, biological activity of the soil were researched; the potential fertility of the soil in terms of energy stored in the "soil-plant" system using soil cover culture as a transformer of photosynthetic activity of plants (PAP) energy into organic matter was estimated; it was determined that the best soil culture for binary watermelon growing is winter rye, which predominates over other cultures by:

- The actual intake of dry organic matter into the soil, which is 1.6 times greater than white mustard and 2.7 times greater than the sowing peas;
- The highest biological activity of the soil in the flowering phase of watermelon, which when applying ½ from the recommended dose of fertilizers and the use of Biogran was 94.9 mg $CO_2/m^2 \times h$;
- The lowest density of soil composition before sowing watermelon in the 0-10 cm horizon was 1.24 g/cm^3, while in the control it was 1.26 g/cm^3;
- Positive effect on the thermal regime of the soil during the period of obtaining watermelon seedlings - ploughing into the soil and mulching between rows with plant mass increases the soil temperature at a depth of 10 cm by 4.2ºC, compared with the control;
- Reduction of weediness of watermelon crops by 55% compared to control;
- An indicator of the intensity of energy accumulation in the system "soil-plant" with the help of soil cover culture, as a transformer of PAP energy into organic matter. The largest amount of solar energy was absorbed by watermelon crops together with winter rye where the utilization rate of PAP was 1.18%, while in the control (without ground cover culture) – 0.93%;
- Watermelon yield of 40.6 t/ha obtained by applying the recommended dose of mineral fertilizers and pre-sowing inoculation of watermelon seeds with Biogran, which is 8.1 t/ha higher than in the control;
- Fruit quality, the highest amount of dry soluble substance and the amount of sugars were contained in fruits obtained from the variant where watermelon was grown with winter rye as a ground cover crop, application of the recommended dose of fertilizers and pre-sowing inoculation of watermelon seeds with bacterial preparation Biogran that composed 9.6% and 8.98% respectively, while the fruits of the control variant, respectively, 8.8% and 7.40%;
- Indicators of economic efficiency, where the introduction of ½ the recommended dose of mineral fertilizers and bacterization of watermelon seeds Biogran obtained the highest net profit of 25568 UAH/ha and profitability of production 78%, at the lowest cost of watermelon 840 UAH/t.

References

[1] Bulygin S Yu, Timchenko D O, Medvediev V V. Ratsionalne vykorystannia I okhorona zemelnykh resursiv, bezpeka agrolandshaftu I selitebnykh terytorii. V kn. Naukovi osnovy agropromyslovoho vyrobnytstva v zoni Stepu Ukrainy. Kyiv: Agrarna nauka; 2004.p.100-212.

[2] Bakhchevye kultury // Pod red. Lymaria A O. Kyiv: Agrarnaia nauka; 2000.p.11-18.

[3] Vitanov A D. Agronomicheskiie aspekty alternate-vnogo zemledeliia v ovoshchevodstve. Naukovi pratsi po ovochivnytstvu. Kharkiv: 1997:Vol.II. p.187-202.

[4] Hamaiunova V V. Zastosuvannia netradytsiinykh vydiv orhanichnykh dobryv v sivozmini – shliakh do zmenshennia antropohennoho navantazhennia na hrunt. "Stalyi rozvytok ahroekolohichnykh system v umovakh obmezhenoho resursnoho zabezpechennia". Mat-ly naukovo metodychnoi konferentsii. Kyiv: 1998.p.79-81.

[5] Dospekhov B A. Metodika polevoho opyta (S osnovamy statystycheskoi obrabotki rezultatov issledovanii) Izd. 4-e, pererab. M.: «Kolos».1979. 416 p.

[6] Kashcheev A. Ya, Revko A S. Udobrenyia arbuza. // Kartofel i ovoshchi. 1979:№ 11.p.38.

[7] Kudzyn Yu K. Vliianye dlitelnoho primeneniia udobrenii na nekotorye svoistva chernozemov i produktyvnost rastenii. V kn. Vliianye dlitelnoho prymeneniia udobrenii na plodorodie pochvy i

produktivnost sevooborotov: MSKh SSSR. M.:1960, №1.p.322-336.

[8] Metodika fiziologicheskikh issledovanii v ovoshchevodstve i bakhchevodstve / Pod red. V F Belyka. M.:1970. 211 p.

[9] Metodyka doslidnoi spravy v ovochivnytstvi i bashtannytstvi / Za redaktsiieiu H L Bondarenka, K I Yakovenka. Kharkiv:Osnova:2001. 369p.

[10] Nosko B S, Buka A Ya, Duda H H. Kompleks ahrozakhodiv – osnova pidvyshchennia rodiuchosti ta okulturennia chornozemiv. V kn.: Yak zberehty i pidvyshchyty rodiuchist chornozemiv /Za red. B S Noska, H S Chesniaka. Kyiv: Urozhai: 1984.p.131-154.

[11] Patyka V P Rekomendatsii po efektyvnomu zastosuvanniu biopreparativ na osnovi azotfiksuiuchykh ta fosformobilizuiuchykh bakterii v suchasnomu resursozberihaiuchomu zemlerobstvi / V P Patyka, M Z Tolkachov, O B Sherstoboeva [ta in.] / TsNTEI. Kyiv.1997.

[12] Patyka V F, Kalynychenko A B, Kolmaz Yu T, Kyslukhyna M V. Rol azotfiksiruiushchikh mikroorhanizmov v povyshenii produktivnosti selskokhoziaistvennykh rastenii / V F Patyka, A B Kalinichenko, Yu T Kolmaz [i dr.] //Mikrobiol. zhurn.:1997:59. № 4.p.3-14.

[13] Pochvy Ukrainy i povyshenie ikh plodorodyia. T. 1. Produktivnost pochv, puti yeio povysheniia, melioratsiia, zashchita pochv ot erozii upravlenie plodorodiem/Pod red. B S Nosko, V V Medvedeva, R S Truskavetskoho, H Ya Chesniaka. Kyiv: Urozhai: 1988. 176 p.

Citation: *Volodymir Lymar, Anatolii Lymar, Ihor Gorbatenko, "Biologized Technology of Watermelon Growing with Drop Irrigation", Research Journal of Food and Nutrition, 4(2), 2020, pp. 20-29.*

Copyright: *© 2020 Volodymir Lymar. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.*