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## **RESEARCH OF WINTER GARLIC STORAGE DEPENDING ON THE ELEMENTS OF THE POST-HARVEST REFINEMENT**

*Об'єктом дослідження є вплив післязбиральної обробки біопрепаратами на збереженість часнику озимого. Одним з найбільш проблемних місць є збільшення терміну зберігання часнику озимого з продовольчою метою та одночасним зменшення ураження хворобами. Обробка продукції біологічними препаратами перед закладанням на зберігання, активні штами яких здатні пригнічувати розвиток захворювань рослин, зменшують втрати продукції під час зберігання.*

*В ході дослідження використовувалися сорти часнику озимого Мерф'янський білий та М'ереф'янський рожевий, вирощені в умовах Лісостепу України. Препарати Гліокладін та Фітоспорин використовували у концентрації 2 % під час веге та перед закладанням на зберігання. Визначали природні втрати, кількість пророслих цибулин часнику та уражених мікробіологічними хворобами, загальні втрати та вихід стандартної продукції.*

*Обробка овочевої продукції біопрепаратами різної дії сприяє подовженню терміну зберігання та збільшенню виходу стандартної продукції у кінці зберігання. Встановлено, що обробка біопрепаратами зменшує ураженість часнику хворобами. Після 6 місяців зберігання необроблені цибулини уражувалися хворобами на 8,33–8,93 %. Обробка Фітоспорином зменшує ураженість мікроорганізмами до 6,28–6,88 %. Найбільш ефективною була обробка цибулин Гліокладіном. Кількість уражених цибулин зменшилася до 2,67–2,69 %. Обробка біопрепаратами найбільш пригнічувала розвиток фузаріозу та бактеріозу. Кількість уражених цибулин становила 0,2–0,65 та 1,1–1,6 %, відповідно.*

*Збереженість часнику озимого має сильний прямий зв'язок з втратою маси, кількістю уражених хворобами та кількістю пророслих цибулин. Запропонована обробка часнику біопрепаратами до зберігання не забезпечує повного винищування шкідливого виду, а лише зниження шкодочинності мікроорганізмів до прийняттого рівня.*

*Запропонований спосіб обробки цибулин часнику біопрепаратами перед зберіганням дозволить зменшити втрати та подовжити період споживання. У розробці нових, низько затратних, екологічно чистих та доступних технологій зберігання це є важливим прийомом.*

**Ключові слова:** обробка біопрепаратами, Гліокладін, Фітоспорин, ураженість мікроорганізмами, втрати маси, подовження терміну зберігання.

Received date: 20.11.2019

Accepted date: 12.12.2019

Published date: 28.02.2020

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### **1. Introduction**

Post-harvest crop preparation prior to implementation occupies an intermediate link in the promotion of vegetables from the farmer's field to the consumer's table. In this part of production, the role of the vegetable grower decreases, and the role of logistics, which puts forward its requirements, gradually grows. The experience of world vegetable growing shows that up to 35 %, that is, a third of the fresh vegetables harvest is lost due to deficiencies during the harvest and without its refinement in the process of promoting the product by the supply chain. Then why increase the area if the rational solution to this problem is the organization of post-harvest refinement? [1].

In recent years, in supermarkets among imported vegetable crops it is possible to see very beautiful Chinese-made garlic. White selected heads of the same size, light, without the slightest sign of aging or deterioration, are stored in stores and on the market for a long time. This result is achieved by treating plants with pesticides containing chlorine. To prevent damage to garlic by harmful insects, it is treated with methyl bromide, a substance banned for use in almost all developed countries in Europe. Interestingly, Chinese garlic is not only not susceptible to decay, but also does not germinate. This is due to the processing of the obtained crop yield by gamma radiation, the effect of which is similar to pasteurization of the product. In this case, the taste and external properties of the fruit remain unchanged.

Therefore, it is relevant to study the drying of garlic to a neck moisture of  $14 \pm 1$  % and the use of antagonist bacteria of the *Pseudomonas* genus to increase garlic bulbs during storage.

## 2. The object of research and its technological audit

*The object of research* is the effect of post-harvest drying of the bulbs and their processing with biological products on the safety of winter garlic.

*Characteristics of «Duchess» winter garlic variety.* Country of Origin: Ukraine. By planting time: winter, ripeness group: early ripe. The advantages of the cultivar are large air bulbs, which, when sown before winter, form single clove with a weight of 5–8 g and about 5 % of the bulbs, are divided into clove. A plant with a flowering arrow 90–120 cm tall forms bulbs weighing 40–50 g and large pods are airy bulbs (weight 1000 pcs. 180 g). Propagated by cloves, air bulbs, single clove.

The leaves are light green 47–48 cm long and 2.2–2.5 cm wide. On one plant, as a rule, 8–10 leaves are formed. The bulbs have a rounded flat shape and are covered with 4–5th dry scales of white color with purple stripes along the vessels (Fig. 1). Bulb weight is 50–60 g. The bulb consists of 5–6 aligned, mainly large cloves, covered with thick parchment light brown scales.



Fig. 1. «Duchess» winter garlic variety

*Merefiansky white garlic variety.* Country of Origin: Ukraine. By planting time: winter, ripeness group: early ripe. Arrowed. Mid-season – the growing season is 105–110 days. Bulb of a wide elliptical shape with weak extraction up, dense. The cloves are large, in the bulb there are 5–6 pieces, placed compactly (Fig. 2). Dry scales of white color, thick enough, dense. The leaves are long, wide, semi-upright.



Fig. 2. Merefiansky winter white garlic variety

*General characteristics of biological products.* Gliocladin (country of origin – Russia) is a microbiological preparation aimed at suppressing the development of bacterial and fungal diseases on plants. Belongs to the class of biological pesticides and bacterial fungicides. Biological product «Gliocladin» has a wide range of actions. It effectively fights against any manifestations of fungal and

bacterial diseases that can affect crops grown in gardens and greenhouses.

*The active substance is the Trichoderma harzianum VIZR-18 fungus.* It suppresses the development of pathogenic microorganisms, the vital processes of which are able to destroy most of the crop.

The drug has a high speed of exposure. Depending on the conditions of humidity and temperature, it has an active effect for 3–7 days. Immediately after processing the fruit, the fungus begins to actively multiply and grow. At this time, it instantly spit on the pathogenic microflora and does not allow it to act, blocks the spread of pathogens. The mode of action of the fungi is that they penetrate into the sclerotia of the pathogenic fungus, and then gradually dissolve from the inside of its cell. In other cases, the fungus of the *Trichoderma harzianum* family encloses a colony of the pathogenic fungus with its hyphae and prevents it from further development, gradually suppressing it.

The negative impact extends only to pathogens. They do no harm to plants and do not affect their condition. Such a reaction is observed only in the presence of appropriate conditions. Spores of Gliocladin fungi are capable of reproduction only in a humid environment. A dry environment and high temperature lead to their death.

Gliocladin is harmless to humans. In addition, it does not cause addiction to the causative agents of diseases, so that it can be used on an ongoing basis for a long time.

Phytosporin (country of origin – Russia) is a microbiological preparation for protecting plants from fungal and bacterial infections, does not contain harmful or aggressive chemicals. Each milliliter of solution contains many live bacteria and spores. An effective biological product not only to protect tomatoes, but also potatoes, cucumbers, zucchini, eggplant, berries. The action of Phytosporin is based on the fact that beneficial bacteria actively destroy pathogens, enveloping plants with a living protective cocoon even when there are no external manifestations of the disease. The tool is available in three forms: powder, paste, suspension. For the effectiveness of Phytosporin, the decisive condition is its proper dilution. It is important to create beneficial bacteria for the most comfortable conditions for awakening and action. A new generation microbiological preparation that is effective against fungal and bacterial diseases in any crops that can spread throughout the vascular system of plants. Its basis is a spore culture; it produces fungicidal oligopeptides and inhibits the reproduction of pathogens of fungal and bacterial plant diseases by the products of its vital activity:

- alternariosis;
- American powdery mildew;
- bacteriosis;
- bacterial spotting (black rot);
- bacterial cancer;
- white spotting (septoria);
- brown rust;
- root rot;
- monolial burn;
- powdery mildew;
- scab;
- peronosporosis (downy mildew);
- penicidal rot;
- rust;
- rhizoctonia;

- snow mold;
- dry and wet rot of tubers;
- tracheomycosis (tracheomycosis wilt);
- late blight;
- phomosis;
- fusarium rot;
- cercosporosis, etc.

And also rot during storage of tubers and bulbs: white rot, gray rot, black dry rot, fruit rot, dry Fusarium rot, etc. [2].

One of the most problematic places is the insufficient study of the effectiveness of the biological preparations Phytosporin and Gliocladin on the safety of vegetables, in particular garlic.

### 3. The aim and objectives of research

The aim of research is the justification of the elements of technology for post-harvest refinement of winter garlic, which will increase the safety and duration of garlic consumption. The working hypothesis is based on the assumption of the possibility of using bacteria-antagonists of the *Pseudomonas* variety to increase garlic bulbs during storage.

To achieve this aim, it is necessary to complete the following tasks:

1. To study the effect of biological products on the defeat of garlic microorganisms during storage.
2. To study the effect of biological products on the types of diseases of winter garlic during storage.

### 4. Research of existing solutions of the problem

One of the simplest and most cost-effective ways to increase the resistance of garlic and onions to adverse conditions is to create a «treatment period» for them after harvesting. During this period, scarring of wounds and injuries during cleaning occurs. The optimal regimen for the «treatment» of garlic and onion is 30 °C and 60–75 %, respectively. Garlic is left in rolls on the field, in very hot sunny weather, which can cause sunburn, under awnings. During this period, the top of the bottom with roots is cut out on garlic. Such garlic without a bottom can be seen in Ukrainian supermarkets [3]. But at the same time, the question of the duration of the treatment period and in which the humidity of the neck is necessary to dry the garlic is not resolved.

Pre-harvest and post-harvest treatment of apple fruit with agrochemicals resulted in a 63.6 and 48.6 % reduction in losses from browning of the apple fruit core during delivery to the consumer after 6 months of storage ( $t=0...1$  °C). The use of an ethylene inhibitor 1-methylcyclopropene increased the resistance of the fruit to disease during storage. The use of foliar top dressing with boric acid and calcium salts together with 1-MCP increased the profitability of long-term storage by 16.9 %, compared with the control [4].

A method of preparing green vegetables for storage is considered in [5]. This method consists in the fact that the greens are stored in plastic bags filled with agricultural hydrogel solutions and antioxidant compositions of ionol and chlorophyllipt, which also allows to reduce losses.

Before biological storage of tomato fruits from gray rot, *Bacillus amyloliquefaciens* bacteria and the *Pichiaguilliermondii*, *Candida guilliermondii*, *C. oleophila* and *Rho-*

*dosporidiumpaludigenum* yeasts are used on them before storage [6]. Before storage, potato tubers are treated with *Bacillus spp.* isolates, which allows the tubers to be kept clean from the dry rot pathogen for up to 8 months [7]. The use of *Aureobasidiumpullulans PL5* halved the loss of plums and peaches from brown rot, and apples from blue and gray mold [8].

An interesting way to prepare potatoes for storage is proposed by Baker and Mackenzie [9]. According to this technology, potatoes for their subsequent storage are treated with a solution of hydrogen peroxide. This technology is environmentally friendly, it prevents losses due to damage and decay caused by pathogenic microorganisms. But in the case of long-term storage, it is advisable to process the potatoes with a solution every few weeks. In addition, in the intervals between such treatments, the potatoes must be maintained in a sterile environment and excessive air humidity.

The work [1] is devoted to increasing the shelf life of vegetable products for food purposes and at the same time reducing the defeat of diseases by treating products with biological preparations before storing them, the active strains of which can inhibit the development of plant diseases. However, questions remained unclear; biological products are most effective at storing garlic.

The authors of [10, 11] show that the use of biological preparations Trichodermin, Planriz and Phytocide during storage of vegetables is an effective environmental alternative. Biological treatment of potato tubers helps to reduce 1.2–1.5 times the loss of mass of starch of dry substances, which allows to obtain high-quality planting material and cost-effective. Phytosporin is a microbiological preparation based on the active endophytic bacterium *Bacillus subtilis* 26. It is intended to protect plants from a complex of fungal and bacterial diseases. Phytosporin has a double action. So, on the one hand, is located in the intercellular space of plants, and, like an endophytic bacterial culture, competitively inhibits the development of many pathogenic microorganisms inside plants. And, on the other hand, in the basal soil environment during the growing season, it inhibits the development of many pathogens, including root rot.

The effect of microbiological products such as Ampelomycin, Vermiculen, Trichodermin, Haupsin, and Planriz on the preservation of potatoes during its long-term storage with cooling is investigated. The storage duration is 145 days. The research results show that all drugs inhibited the development of microbiological processes and contributed to a decrease in respiration rate, which led to a decrease in the natural loss of the product and loss from spoilage. It is found that the best product for inhibition of microbiological and physiological processes has the biological product Planriz, the basis of which is microorganisms of the genus *Pseudomonas fluorescence*. A biological preparation Trichodermin, which is based on the fungus *Trichoderma lignorum*, which inhibits the development of phytopathogens by direct parasitization, competition for the substrate, the release of enzymes, antibiotics (gliotoxin, viridin) and other biologically active substances, is also a promising drug for protecting plants against a wide range of fungal and bacterial diseases [12].

When processing Planriz, a decrease in the intensity of redox reactions is observed, as well as stabilization of carbon metabolism, helps to reduce overall absolute

losses and allows to extend shelf life, and is observed during storage of apples. During the entire shelf life, the amount of sucrose in the processed apples grew, but in the control decreased, while at the initial stage the sugar accumulated both due to sucrose and sugars, they are restored. The results of the commodity analysis of the studied products confirm the antifungicidal activity of the Planrizdrug [13].

So, the question of drying out winter garlic remains a problem. And also there are no recommendations for which the humidity of the neck of the bulb must be dried garlic. The normative documents do not standardize the natural loss of garlic, regulating them during the period from collection to bookmark storage.

It can be noted that scientific information on the use of antimicrobial preparations on the safety and quality of broccoli is not enough. The reason is that such studies have not been conducted. Processing fruit and vegetable products before storage with antimicrobial agents has a number of disadvantages. Namely: they do not protect the fruits from physiological disorders during storage. Changes in the components of the chemical composition in the above studies were not carried out. Biological agents are not intended to completely exterminate microorganisms, but only to reduce harmfulness to an acceptable level. The disadvantage of this method is a significant increase in the cost of production.

Therefore, it is important to investigate the effect of antimicrobial agents on weight loss, changes in the chemical composition of broccoli cabbage, damage by microorganisms and physiological disorders during storage.

## 5. Methods of research

Field experiments were carried out on the experimental field, in the eastern part of the Left-Bank Forest-Steppe of Ukraine in the Kharkiv region using drip irrigation. Laboratory experiments were carried out at the T. P. Evsyukov Department of Optimization of Technological Systems of the Kharkiv Petro Vasylenko National Technical University of Agriculture (Ukraine).

The climate of the region where the studies were conducted is characterized as temperate continental with unstable humidification and air temperature. The average long-term air temperature is 7.2 °C. The coldest month is January, its average long-term temperature is minus 6.9 °C. The average annual rainfall is 529 mm, in acutely dry years – 253 and up to 804 mm – in excessively wet years. The minimum amount of precipitation falls in February, the maximum – in June, July, August. The average annual rainfall is distributed as follows: in winter, 16–20 %, in spring, 22–25 %, in summer, 35–40 %, in autumn, 35–40 %. The accumulation of moisture in the soil depends mainly on autumn-winter precipitation, the amount of which reaches 40 % per annum.

Field experiments were carried out according to generally accepted methods [14]. With varieties of winter garlic Merefiansky white, Merefiansky pink (Duchesse), included in the State Register of plant varieties suitable for distribution in Ukraine [15]. Garlic was harvested in the third decade of July with yellowing of the lower leaves. Humidity of the neck of the bulb is  $52 \pm 2$  %. On drying, garlic with stems and edged with a stem 2.5 cm tall was laid. Dried out winter garlic was carried out

according to the Methodology of research in vegetable growing [16]. The weight of the registration sample is 3 kg, with stems – 5 kg, four repetitions.

Garlic was dried on a wire mesh in a greenhouse. Drying takes 15–30 days. Dried to bulb neck moisture of  $25 \pm 1$  % and  $14 \pm 1$  % until the stems hardened. Full hardening is completed when the outer skin is dry and crisp, the neck is narrowed, and the center of the cut of the leg is hard. The preparations Gliocladin and Phyto-sporin were used at a concentration of 2 % during the growing season and before being stored.

After drying, the garlic was stored in a Polair refrigerator (manufacturer Russia) at a temperature of  $-1...-3 \pm 0.5$  °C and a relative humidity of 75–80 % in plastic boxes No. 6 (GOST 10-15-86) [17, 18]. The weight of the registration sample was 3 kg, the repetition was fourfold. Standard heads of garlic in a diameter of at least 2.5 cm were selected. The nets were numbered, weighed and placed in the mass of the product [19].

Observation of garlic was carried out in dynamics after 120 and 180 days. Sampling and preparation of samples for analysis was carried out in accordance with DSTU ISO 874-2002 [20]. The value of the natural loss of mass during storage was determined by the method of fixed samples [21].

The natural decrease, the number of sprouted garlic bulbs and affected by microbiological diseases, the total losses, as well as the yield of standard products according to the methods generally accepted in vegetable growing with microscopic identification of the pathogen were determined during storage.

Natural weight loss was determined as a percentage of the initial weight. The sample was removed for storage if the natural loss of mass reached 10 % or more and the product had signs of damage to diseases and physiological disorders. At the end of storage, the yield of standard products was determined [21].

When analyzing and processing experimental data and predicting the final result, methods of variation statistics were used. They also performed mathematical processing, paired and multiple correlation and regression analyzes [22] using computer programs «MS office Excel 2007», the package «Statistica 6» and a personal computer.

## 6. Research results

During storage of vegetables, significant losses from damage by microorganisms occur [22, 23]. An important role is played by changes in the biology of the causative agents of diseases, which are expressed in an increase in their resistance, plasticity, adaptability, and pathogenicity [24, 25]. An important role in suppressing the development of diseases of garlic plants is played by microorganisms of the *Pseudomonas sp.* and *T. Trichoderma sp.* genus [26].

It is proved that isolates of the genus *Trichoderma sp.* are able to induce plant resistance to pathogens of *Fusarium oxysporum* Schlecht. In experiments [27] with the use of a 1 % *Trichodermin* solution, an increase in sugar beet productivity by 1.7–3.6 times was revealed, when laying them for storage, a 1.6-fold delay in the development of fungal and bacterial rot was observed compared with untreated variants.

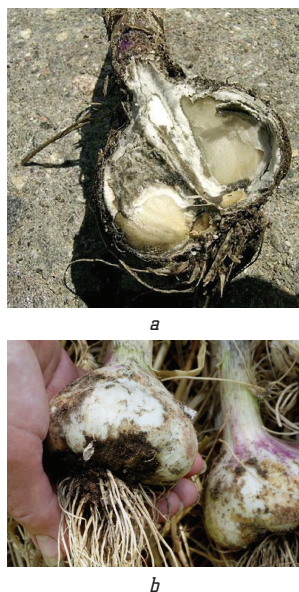
As shown in the Table 1, the treatment of bulbs with biological preparations inhibits the defeat of garlic diseases.

**Table 1**  
Infection of winter garlic bulbs with diseases depending on post-harvest treatment with biological products at a storage temperature of  $-1...-3$  °C, %

Variant	Types of diseases				Total
	bacteriosis	fusarium	white rot	gray rot	
After four months of storage					
Merefiansky pink (Duchess)					
Control	1.3	0.53	1.5	2.0	5.33
Gliocladin 2 %	0.9	0.2	0.5	0.47	2.07
Phytosporin 2 %	0.2	0.12	0.1	0.1	0.52
Merefiansky white					
Control	1.6	0.13	1.7	1.9	5.33
Gliocladin 2 %	1.0	0.07	0.8	0.7	2.67
Phytosporin 2 %	0.12	0.1	0.4	0.3	0.92
After six months of storage					
Merefiansky pink (Duchess)					
Control	2.1	0.93	2.6	2.7	8.33
Gliocladin 2 %	1.0	0.2	0.54	0.55	2.29
Phytosporin 2 %	0.5	0.5	2.75	2.53	6.28
Merefiansky white					
Control	2.1	1.2	2.7	2.93	8.93
Gliocladin 2 %	1.1	0.2	0.82	0.77	2.89
Phytosporin 2 %	0.95	0.65	2.15	3.13	6.88

Among the diseases that affect the garlic bulbs during storage are white color and gray rot of the bulb bottom, fusarium, bacteriosis.

*White rot of the bottom.* During storage of garlic, the disease manifests itself on individual bulbs in the form of flooding and decay of the bottom, on which a white loose coating with black sclerotia of the fungus also appears. Bulb rot always starts from the bottom. Subsequently, diseased bulbs completely rot. Gliocladin treatment with 2 % depressed bulb damage to 0.54–0.82 %, while Phytosporin treatment 2 % did not significantly affect the development of white rot (Fig. 3).



**Fig. 3.** Bulbs of garlic affected by white rot: *a* – the spread of rot inside the bulb; *b* – the manifestation of the disease on the basal part of the false stem

*Fusarium.* On a clove of garlic, the disease manifests itself in the form of necrotic spots, first in the form of dots or ulcers of a small size, then during storage the mycelium grows, the spots increase and rot spreads throughout the entire clove. In the basal part of the false stem, there are superficial light yellow or brown spots, on which, in wet weather, white-pink or reddish plaque appears at the base of puff sheaths – conidial sporulation of pathogens (Fig. 4).



**Fig. 4.** Garlic bulbs affected by fusarium

Treatment with Gliocladin 2 % and Phytosporin 2 % significantly influenced the development of fusarium during storage of garlic. Fusarium infection was observed less than 0.07–0.65 %.

*Bacteriosis.* The disease is spread to garlic and onions, especially during storage of bulbs. The primary infection of the bulbs occurs in the field. Around the stem end of the affected bulb, a large, light or slightly pinkish spot forms (Fig. 5) [28].



**Fig. 5.** Bulbs of garlic affected by bacteriosis

Treatment with Phytosporin 2 % had a greater effect on the development of the disease compared with treatment with Gliocladin 2 %. The number of bulbs affected by bacteriosis at the end of storage was 0.5–0.95 %.

*Gray rot.* An abundant white mycelium develops in the region of the bulb base, the bulbs soften. Rot can continue to develop when storing a garlic crop. On the head of the bulb gray spots appear, which eventually cover all the cloves. The softening of the clove begins from above, they acquire a watery consistency, a sharp unpleasant odor. At this stage, gray rot captures the entire top of the head of garlic (Fig. 6).

It was found that treatment with biological products reduces the incidence of garlic diseases. After six months of storage, the untreated bulbs defied themselves with diseases of 8.33–8.93 %. Treatment with Phytosporin reduced the

incidence of microorganisms to 6.28–6.88 %. The most effective was the treatment of bulbs with Glyoclazine. The number of affected bulbs decreased to 2.67–2.69 %. Biologic treatment most inhibited the development of fusarium. The number of affected bulbs was 0.2–0.65 %.



Fig. 6. Garlic bulbs affected by gray rot

The optimal degree of activity of bioagents on pathogens of vegetable crops is determined by many factors [29]. For example, one of the environmental factors that can inhibit *Trichoderma* activity is soil temperature. It was established that the maximum manifestation temperature for the activity of the fungus *Trichoderma viride* – the component of Trichodermin drug is 28–34 °C, the minimum –5 °C, for the bacterium *Pseudomonas aureofaciens* IMB 2617 – the component of the drug Glyocladin this indicator is 22–25 °C [30]. At that time, the data on the minimum temperature for the development and action of the active components of biological preparations in the literature vary. It should be noted that biological preparations are not very effective against the background of a very high infectious load of phytopathogens. So, the preparations used in the work can have fungicidal, and, probably, adaptive properties on garlic plants.

A correlation analysis showed that the safety of winter garlic has a strong direct relationship with weight loss, the number of affected diseases and the number of sprouted bulbs (Table 2).

Table 2

The degree of relationship between variable quality attributes during garlic storage

–	$x_1$	$x_2$	$x_3$	$x_4$	$x_5$	$x_6$
$x_1$	1	–	–	–	–	–
$x_2$	0.83194	1	–	–	–	–
$x_3$	0.87904	0.897293	1	–	–	–
$x_4$	0.74864	0.661449	0.862162	1	–	–
$x_5$	0.895345	0.91017	0.989775	0.89726	1	–
$x_6$	–0.89533	–0.91025	–0.98974	–0.89725	–1	1

Note:  $x_1$  – mass loss, %;  $x_2$  – the number of diseased, %;  $x_3$  – the number of sprouted bulbs, %;  $x_4$  – total loss, %;  $x_5$  – output of marketable products, %

Similar studies were conducted with onions. The smallest number of diseased bulbs as compared to the control (without treatment 4.9 %) was noted with Haupsin (0.5 %),

then Planriz and Trichodermin – 0.9 %, and with phytoncides, the number of bulbs affected by diseases reached 2.3 % [30]. The use of biological products in the cultivation and storage of potatoes of the Scarbnytsia variety decreased by 1.7–1.8 times, and in the Lileia variety – by 2.4–3.5 times.

## 7. SWOT analysis of research results

**Strengths.** The development of ecological and uncomplicated elements of technology for storing winter garlic is essential and important. Let's note that the use of microbial biological products almost does not require changes in the technology of post-harvest processing of vegetables. Biological treatment reduces the number of products affected by diseases, and therefore extends the shelf life.

**Weaknesses.** By composition, preparations are living microorganisms, with biologically active products of their vital functions. Therefore, microbial preparations without observing the mandatory conditions for their storage and use may lose their properties. Biological agents are not intended to completely exterminate a harmful species, but only to reduce the harmfulness of microorganisms to an acceptable level. The main thing is to take into account their composition. The biological method is considered as an integral part of the fight against pests.

**Opportunities.** Processing vegetables with biological products does not inhibit the evaporation of water during storage. The problem can be solved by processing a film-forming coating in a composition with biological products. Such a coating will allow creating a moisture-retaining and gas-permeable film on the product surface for each product instance separately. The consequence is inhibition of biochemical and decrease in the consumption of substances for metabolic processes.

**Threats.** It can be noted that scientific information on post-harvest drying of bulbs, the use of biological products with antimicrobial effects on the safety and quality of garlic is not enough. This is explained by the fact that no such studies have been conducted. The disadvantage of the study is the lack of results of changes in the components of the chemical composition of garlic during post-harvest processing and storage. Therefore, it is important to study the effect of the drying of bulbs and biological products of antimicrobial action on the change in the chemical composition of winter garlic.

## 8. Conclusions

1. It is found that treatment with biological products reduces the incidence of garlic diseases. After 6 months of storage, the untreated bulbs defied themselves with diseases of 8.33–8.93 %. Treatment with Phytosporin reduced the incidence of microorganisms to 6.28–6.88 %. The most effective was the treatment of bulbs with Glyoclazine. The number of affected bulbs decreases to 2.67–2.69 %. The safety of winter garlic has a strong direct relationship with the number of diseased garlic bulbs.

2. It is shown that among the diseases that affect the garlic bulbs during storage, white color and gray rot of the bulb bottom, fusarium, bacteriosis. Treatment with Gliocladin 2 % and Phytosporin 2 % significantly influenced the development of fusarium during storage of garlic. Fusarium infection is observed less than 0.07–0.65 %.

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