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ABSTRACT

of the dissertation submitted for the degree of Doctor of Philosophy

STUDYING THE CULTIVATION TECHNOLOGY OF THE GROUNDNUT PLANT (*ARACHİS HYPOGAEA* L.) IN THE GANJA-GAZAKH REGION

Speciality: 3103.07 – **Plant growing**

Field of science: **Agrarian sciences**

Pretender: **Raqsana Vaqif Namazova**

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Dissertation work was carried out in 2016-2019 at the Educational Experimental Farm of Azerbaijan State Agrarian University

Scientific leader: doctor of agrarian sciences, professor
Nizami Yaqub Seyidaliyev

Official opponents: corresponding member of ANAS,
doctor of biological sciences, professor
Vagif Seyfaddin Novruzov

Doctor of Philosophy on agrarian sciences,
associate professor
Javid Ali Agakishiyev

Doctor of Philosophy on agrarian sciences
Nargiz Musa Abdullayeva

FD 1.29 Dissertation Council operating under the Research Institute of Crop Husbandry of the Ministry of Agriculture of the Republic of Azerbaijan of The Higher Attestation Commission under the President of the Republic of Azerbaijan.

Chairman of the Dissertation Council:
Doctor of Agrarian Sciences, professor
Jalal Shamil Mammadov

Scientific Secretary of the Dissertation Council:
Doctor of Philosophy on agrarian sciences, assistant professor
Sevda Kamal Hajiyeva

Chairman of the scientific seminar:
Doctor of agrarian sciences,
assistant professor
Islam Akif Bayahmadov

GENERAL CHARACTERISTICS OF THE WORK

The actuality and degree of using of the topic. Groundnut or Arachis (Arachis hypogaea L.) are planted and cultivated to obtain edible oil. Groundnut seeds contain up to 60% fat (on average 53%) and more than 35% protein. In terms of protein content, groundnut is second only to soybean. Groundnut oil is used in canning industry, margarine making, soap making industry and medicine. Groundnut oil belongs to the group of semi-drying (iodine number 90-103) oils. On average, 226-317 kg of oil is obtained from one ton of shelled groundnut seeds. After oil processing, oilcake contains 45% protein and 8% fat. Oilcake and stems (chopped straw) of groundnut are used as fodder in animal husbandry. Chopped straw contains up to 11% protein and is not inferior to alfalfa (black clover) and three-leaf clover in terms of nutritional quality. Oilcake is used as insulation material and fuel.[1]

The types of plants planted in agrophytocenoses are of particular importance in the matter of the relationship. Such species play an important role in the agricultural system. Cultivation of plants containing high-quality fat and protein is of great importance in the Ganja-Gazakh region of Azerbaijan.

Groundnuts contain high amounts of protein (up to 45%) rich in essential amino acids. The groundnut plant accumulates a large amount of organic matter, which has a good effect on soil fertility. The main research factor in the content of agrophytocenoses in the Ganja-Gazakh region is the correct study of ecological conditions and full consideration of the biological characteristics of plants. The study of these issues is one of the actual problems in modern agriculture.

Research goals and objectives. The purpose of the research is to develop the scientific and theoretical bases of the prospects of using the groundnut plant in joint croppings in the ecosystems of the Ganja-Gazakh region.

[1] H.S.Humbatov, Oily and essential oil plants. Textbook / H.S.Humbatov, V.V.Bashirov, V.R.Mohumayev. – Baku: Science and Education, - 2016, - p.34-41.

In order to achieve the solution of the issues envisaged in the research work, the following main tasks have been set:

Justification of the possibility of co-planting groundnut with other plants and studying its yield characteristics;

Investigating the possibilities of groundnut yield management in joint cropping;

Clarification of the characteristics and function of the formation of the symbiotic apparatus of groundnut;

Studying the effect of environmental conditions on the yield characteristics of groundnut seeds;

Assessment of energy and economic efficiency of groundnut cultivation in agrophytocenoses.

Research methods. The experiments were conducted according to the general methods adopted for this type of research. Analyzes of soil and plant samples in the laboratory of the Department of Soil Science and Agrochemistry of ASAU: Activated

Phosphorus According to B.P. Machigin, activated potassium according to C.M.Huseynov, pH, with a pH meter; the amount of absorbed bases was determined by titration with the Trilon "B" method, determination of humus according to Turin, determination of nitrate nitrogen in the soil by Grandval-Lyaju, enzymatic activity of the soil by the method of M.M.Kononova, the amount of oil in groundnut seeds was determined by the Soxhlet apparatus, the amount of protein in the seed was determined by the protein separation method. Mathematical calculation of the obtained results, correlation and dispersion analyzes were performed by the B.A.Dospexov method.

The main provisions defended:

The main provisions defended are the following:

- Studying the productivity and the formation characteristics of agrophytocenoses productivity in joint crops;
- Observation of the formation and function of the groundnut symbiotic apparatus in joint crops;
- Plant productivity and yield quality analysis in joint crops;
- Studying of sowing quality and productivity characteristics of groundnut seeds in joint crops;

- Energetic assessment of agrophytocenoses in joint crops and the economic efficiency of the experiment;

Scientific novelty of the research. For the first time in the study, based on the analysis of agroclimatic resources and biological properties of groundnut in the irrigated gray-brown (chestnut) soils of the Ganja-Gazakh region, the possibility of its use in joint crops of this region was determined. Productivity characteristics of groundnut in pure and joint plantings, main environmental factors influencing the formation and function of the symbiotic apparatus and yield characteristics of groundnut seeds were studied.

Theoretical and practical significance of research. Based on the results obtained from the conducted research, the ways of using the groundnut plant in the agrophytocenoses of the Ganja-Gazakh region were recommended. The unique characteristics of planting groundnuts together with tomato and potato plants have been substantiated.

Approbation and application. The results of the conducted research at the annual report meetings of the department of plant breeding and plant protection of the Azerbaijan State Agrarian University (Ganja, 2016-2019), at the scientific conference under the name "New challenges in botanical research" dedicated to the 90th anniversary of academician Vahid Jalal oglu Hajiyev, jointly organized by the Institute of Botany of ANAS and the Society of Botanists of Azerbaijan (Baku, June 20-21, 2018), at the Republican scientific-practical conference on "Academician Jalal Aliyev and the genetic resources of biological diversity" dedicated to the 90th anniversary of the birth of Academician Jalal Alirza Aliyev (Ganja, November 30, 2018), the Ministry of Education of the Republic of Azerbaijan, at the International scientific conference on "Actual problems of modern nature and economic sciences" dedicated to the 96th anniversary of the birth of national leader Heydar Aliyev, held at the Ganja State University (Ganja, May 03-04, 2019), at the scientific-practical conference on the results of the 2018 scientific-research works of ASAU employees dedicated to the 96th anniversary of the national leader Heydar Aliyev's birth (Ganja, May 7, 2019), at XXXVIII International scientific conference "Modern sci-

entific challenges and innovations" (May 07-09, 2021, Warsaw - Poland), at XLIII International scientific-practical conference "Russian science in the modern world" January 15, 2022, Moscow, Russia) were reported and discussed at the Scientific seminar of the Agricultural Research Institute of the Ministry of Agriculture (September 6, 2022).

In 2019, the optimal options identified as a result of the research were tested under production conditions in farms of Goranboy and Shamkir regions, and positive results were obtained. The obtained results were close to the results obtained when the experiment was set at a high agrophone.

The name of the institution where the dissertation work was performed.

Dissertation work was carried out in 2016-2019 at the Educational Experimental Farm of Azerbaijan State Agrarian University.

The total volume of the dissertation with a sign indicating the volume of the structural sections of the dissertation separately. The dissertation consists of an introduction, four chapters, conclusions, recommendations for farms, a list of used literature and appendices. The main text of the dissertation consists of 131 computer pages, including 27 tables, 3 graphs, and 8 figures. In 130 names, including Azerbaijan in 29 names, CIS in 31 names, foreign literature sources in 42 names, and internet sites in 28 names were used. In the appendices section, 30 pages of indicators of individual signs by year, results of correlation dependence between signs, pictures and application acts are given. In the structure of the dissertation, the title part and the table of contents are 1 page each and consist of 1368 characters, the introduction is 5 pages of 9102 characters, the first chapter is 35 pages of 75460 characters, the second chapter is 9 pages of 17252 characters, the third chapter is 4 pages of 6130 characters, the fourth chapter is 64 pages of 112310 characters, conclusions and proposals are 2 pages and 3936 characters, the list of 130 used literature is 10 pages and 18648 characters, and the appendices section is 30 pages and 22783 characters. The total volume of the dissertation consists of 161 pages of computer writing. The general text part of the dissertation (excluding pictures, tables, graphs, appendices and the bibliography) is 103

pages of computer writing or 211771 characters.

MAIN CONTENTS OF THE WORK

In the introductory part of the dissertation, a short description of the topicality of the work is given, and its scientific and practical significance is indicated.

Chapter I. Ecological characteristics of the groundnut plant and methods of cultivation. This chapter is a summary of literature, and the ecological characteristics and cultivation methods of the groundnut plant, the importance, history, distribution, systematization, morphological, biological and ecological characteristics of this plant, as well as the results of scientific research conducted in our country and abroad on cultivation methods are summarized and reflected.

Chapter II. Soil - climate conditions of Ganja - Gazakh region. In this section, detailed information is provided on the types of soil common in Ganja - Gazakh region, climate conditions and vegetation of the region in 2016-2018.

Chapter III. Research methodology and conditions.

Experimental studies were carried out at the Azerbaijan State Agrarian University (ASAU) in 2016-2019. Field experiments were carried out in the lands of the Ganja-Gazakh region of the Republic of Azerbaijan.

The studies were conducted according to generally accepted methods. As a research object, the variety “Zagatala 294/1” of the groundnut plant, regionalized in the Republic of Azerbaijan since 1945 (medium maturity, 130-144 days), the half fast-growing Telman variety of potato plant, regionalized since 2009 (110-120 days), fast-growing “Elnur” regionalized in 2000, half-ripe “Titan” regionalized in 1989 and half-ripe "Khazar" variety of tomato plant regionalized in 2011 were selected.

The experience is set in the following options:

1. Groundnut (clean sowing) - control; 2. Fresh tomato; 3. half-ripe tomato; 4. Half fast-growing tomato; 5. Potato; 6. Groundnut + fast- growing tomato; 7. Groundnut + half fast-growing tomato; 8. Groundnut + half-ripe tomato; 9. Peanut + potato.

Experiments were carried out in 4 repetitions, with winter wheat as the predecessor plant. The options were systematically placed and the area of the experimental bed was 50 m^2. The potato and tomato plants to be used in the experiment were cared for according to the general agrotechnical rules adopted for the region.

In joint cultivation, the potato planting rate is 30,000 tubers per hectare, and in pure planting, it is 60,000 tubers per hectare. 35,000 tomato seedlings per hectare were planted in joint cultivation, and 70,000 tomato seedlings were planted in pure cultivation.

Potato tubers were buried in the sowing layer of the soil (5 cm layer) at a temperature of 60 ^{0}C for 3 days.

The groundnut (arachis) seeds to be sown had laboratory germination energy of more than 90%, and the germination capacity was more than 70%. They were sown in a 10 cm layer of soil at a temperature of 15 ^{0}C. Tomato seedlings were also buried during this period.

The groundnut sowing method was carried out by the square nest (70x70 cm) method in pure planting, and by the wide row method (70 cm between rows, 70 cm between plants in a row) in joint planting.

200-240 thousand pieces of groundnut seeds were sown per hectare in pure sowing, and 100-120 thousand pieces in joint sowing, the seeds were buried 5-6 cm deep, 4-5 seeds were placed in each nest. In joint crops, one plant was planted in each row.

The main indicators of the photosynthetic activity of plants, phytopathological reports based on the methodology[2] of the state variety test of agricultural plants, Posypanov's method[3] of reporting of the activity and the growth of the symbiotic apparatus was used to evaluate the development of the symbiotic apparatus.

The groundnut crop is harvested by hand. The time of harvesting is determined by the good filling of the cotyledons, the firmness of the cotyledons, the presence of a visible web on the surface of the

[2] Methodology of state variety testing of agricultural crops. – M.: Chemistry, 1989, - 240p.

[3] Posypanov, G. S. Methods for studying the biological fixation of nitrogen in the air/ Reference manual. M.: Agropromizdat, 1991, - 230p.

cotyledons, and the yellow color of the cotyledons.

The collected cotyledons were spread in a layer of 5-7 cm, dried and their mass was determined. After drying, the cotyledons are separated by hand or with simple devices. The drying of incompletely dried cotyledons was continued. The moisture content of seeds cleaned from cotyledons and soil should not exceed 8%.

The yield of potato and tomato plants was also collected by hand and weighed and the mass was determined.

Soil and plant samples were taken for analysis during the vegetation period and after harvest.

Agrochemical analyzes of soil and plant samples were conducted in the laboratory of the Department of Soil Science and Agrochemistry of ASAU based on existing methods. Mathematical calculation of the results obtained from the experiment was carried out on the basis of appropriate programs on the computer, with the correlation and dispersion analyzes carried out by the Dospexov method.[4]

Chapter IV. Results of the experiment

4.1. Features of formation of productivity of agrophytocenoses

4.1.1. Productivity processes of agrophytocenoses. High production of complex agrocenoses (plant life) occurs in conditions where they are optimally sized and the photosynthetic apparatus (leaf area) works intensively and qualitatively in different phases of plant development, causes little loss of photosynthesis products in the process of movement, general metabolism, plant growth and creates conditions for its development and, as a result, the formation of productivity.

The conducted observations suggest that the changes occurring in the environment to one degree or another are reflected in the development and condition of the assimilation apparatus, primarily in the dimensions of the leaf surface.

Plant productivity also depends on the leaf surface area.[5] The

[4] Dospekhov, B. A. Methods of field experience. Moscow: Agropromizdat, - 1985. - 351 p.

[5] Namazova, R.V. Features of productivity formation in Arakhis agrophytocenoses // - Ganja: ANAS-Ganja branch. News collection No. 1 (71), - 2018. - p. 94-99.

largest assimilation area in the leaves of the groundnut plant is observed at the beginning of flowering when planted together with early ripening tomatoes (19.7 thousand m^2/ha).

This is 43.8% higher than the leaf area in pure groundnut planting, 16.6% compared to half-ripening tomato planting, 50.4% compared to planting with half-early ripening tomatoes, and 34.9% compared to planting with potatoes. An increase in leaf area was also observed when potato and tomato were interspersed with groundnut. In particular, the index of the leaf surface (ILS-1 is measured in m^2 per square meter area), which determines the activity of solar radiation absorption in potato increased by 11.6% and in tomato by 10.7-16.0%. Thus, these plants have a positive interaction with each other.

The groundnut plant is one of those plants that the decreasing of vegetative mass, the formation of generative organs, flowering and fruiting processes occur at the same time. Therefore, the growth of the leaf surface in groundnut continues until the cotyledons mature. But this is not so important. It is 3% in single (pure) planting of groundnuts, 6.1% in planting together with potatoes, and 5.6-6.9% in planting with tomatoes. This also shows that the continuation of the function of the leaf apparatus in conditions of joint planting (polyculture) is longer than in pure (single) plantings. In 2016, the total leaf surface area of plants in agrocenosis was 32.1-41.3 thousand m^2/ha, and in 2017 it was 32.8-42.1 thousand m^2/ha. In the period from flowering to fruiting, the growth of the plant's photosynthetic apparatus is often determined by its previous year's development. Meteorological conditions are generally favorable for the further development of the leaf surface.

In 2016, the leaf surface area of groundnut at the beginning of fruit development was 12.6-19.7 thousand m^2/ha, in 2017 it was 15.3-21.8 thousand m^2/ha, and in 2018 it was 20.4-29.3 thousand m^2/ha. The correlation (dependence) coefficient between leaf surface area and seed yield was +0.41±0.377 in 2016, +0.15±0.44 in 2017, and +0.45±0.36 in 2018.

In groundnut plant, the assimilation surface continues to grow until the cotyledon ripening phase (12.9-20.2 thousand m^2/ha in 2016,

15.9-22.4 thousand m^2/ha in 2017, and 21.8-32.3 thousand m^2/ha in 2018), but during this period the leaf surface area of the potato plant decreases. Our experiments show that maximum photosynthetic potential of groundnut plant at the beginning of cotyledon formation was formed in joint planting with early-ripening tomato. This indicator was 541.3 thousand m^2/ha day, which is 42.1% higher than pure (single) planting. In 2016, the correlation (dependence) coefficient between the photosynthetic potential (photosynthesizing potential) and seed yield of groundnuts was +0.42±0.37 in 2016; +0.21±0.43 in 2017; it was between +0.43±0.36 in 2018. The development of the photosynthetic apparatus of the groundnut plant continues from the time the sprouts are received to the ripening of the seeds. The most (maximum) assimilation surface in leaves (20.2-32.3 thousand m^2/ha) is created in joint planting of groundnuts with fast-growing tomatoes.

In 2016, the leaf surface area in joint planting increased by 8.2-12.3% in potatoes, and by 11.9-15.8% in tomatoes. In 2017, this indicator was 12.4-19.8% for plants, and it was 5.8-16.7% in 2018.

At the beginning of the fruiting phase, the correlation coefficient between groundnut leaf surface area and seed yield was +0.34 ± 0.39 on average for years, and the correlation coefficient between photosynthetic potential and seed yield was +0.35 ± 0.38 on average for years. The amount of harmful plants (weeds) in joint plantings of groundnut with fast-growing tomatoes decreased by 42.4-51.2% compared to pure (single) plantings of legumes (groundnut).

In the ripening phase, the photosynthetic potential of the groundnut + fast-growing tomato option was equal to 728.5 thousand m^2/ha day, which is 10.9-42.4% higher than other agrophytocenoses. However, the photosynthetic potential of groundnut is very low compared to tomato and potato. From this, we can draw a preliminary conclusion that its productivity should be lower than that of potatoes and tomatoes.

At the beginning of flowering, the net productivity of photosynthesis in the groundnut plant was 0.9-1.3 g/m^2 per day, and it reached

the maximum level (1.3 g/m^2 per day) in joint planting with potatoes.[6]

At the beginning of fruit formation, the productivity of agrophytocenoses increased by 2.7-3.4 g/m^2 per day.

The average daily growth of phytomass (2.7 g/m^2 per day) in joint plantings of groundnuts with fast-growing and half-growing tomatoes is 20.6% lower than in joint plantings of groundnuts with potatoes and half-growing tomatoes. In the ripening phase, the pure (net) productivity of photosynthesis in the groundnut plant decreased by 1.5-1.9 g/m^2 per day. During this time, there is a large interval in the functioning (function) of the leaf in joint plantings of legumes with half-ripening tomatoes and potatoes.

The amount of segetal (weed) (from the Latin segetalis meaning growing between grains) plants in joint plantings of groundnut with fast-growing tomatoes was 42.4-51.2% less than in its pure plantings (table 1).

Table 1

Amount of segetal (weed) plants in agrophytocenoses at the beginning of the fruiting phase of the groundnut plant (numbers in m^2)

Variants	Amount of segetal (weed) plants			
	2016	**2017**	**2018**	**Average**
Groundnut (pure sowing)	10,1	9,2	13,1	10,8
Fast-growing tomato	11,2	10,4	12,6	11,3
Half fast-growing tomato	10,5	9,4	11,8	10,5
Half-ripening tomato	10,5	10,8	12,8	11,3
Potato	10,2	9,7	11,9	10,5
Groundnut+fast-growing tomato	5,2	5,3	6,4	5,6
Groundnut + half fast-growing tomato	7,6	6,7	8,3	7,6
Groundnut+ half-ripening tomato	7,0	7,4	9,1	7,9
Groundnut + potato	6,2	6,0	7,6	6,6

[6] Namazova, R.V. Productivity of plants in mixed plantings of peanuts // Scientific practical conference on the results of the 2018 scientific-research works of ASAU employees dedicated to the 96th anniversary of the birth of national leader Heydar Aliyev, - Ganja: - May 7, 2019, - p. 20-21.

In particular, field thistle was 33.3 - 69.6%, field ivy 32.7-49.2%, creeping agropyron 53.8-60.0% less.

During joint planting of groundnuts with eggplant plants (potatoes, tomatoes), the phytophthora disease of tomato plants decreased by 0.7-29.8%, and the infection of potatoes by 26.2-32.2%.

4.1.2. Formation and function of the groundnut symbiotic apparatus. Special attention was paid to the development of the symbiotic apparatus (the interaction between the plant and root tuber bacteria) during the analysis of the characteristics of the formation of the yield of groundnut crops. The symbiotic apparatus is considered an indicator of the compatibility of the biological properties of the plant with the ecological conditions of the area.

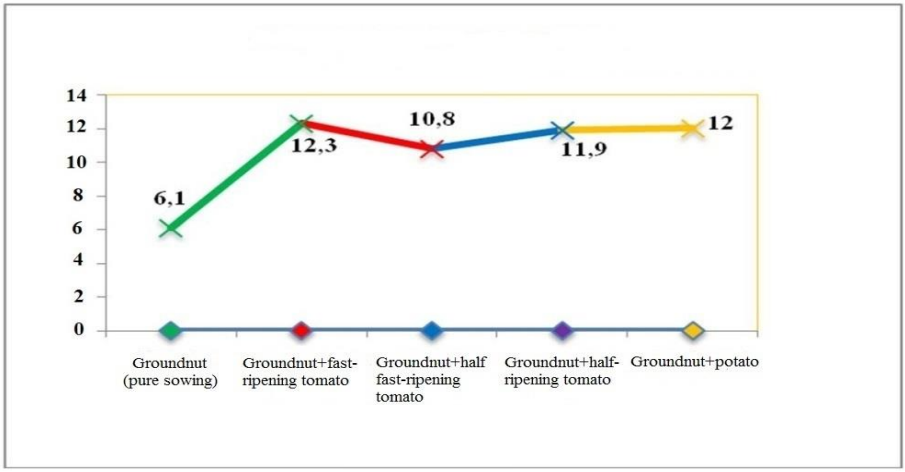
The groundnut plant, like other legumes, produces large numbers of nodules (root nodules) on its roots when given favorable conditions. These nodules are created by a special group of viable bacteria that have adapted to the roots of the groundnut plant and are formed only when the necessary conditions are met.

As a result of the life activity of tuber bacteria, tumors are formed under cotyledon, as well as in the central and lateral root branches of the first row close to the main root. At first, the bacteria are located at the tip of the roots and begin to multiply quickly. Here they go through a certain development period and turn from cocci into normal cocci and then again into a small cocci form. They are collected in the form of pulp (soft) on the root strands. They are also called infection threads.

They develop quickly and enter the root through the wall of small cells. Under the influence of tuber bacteria, the division of stem cells accelerates and many new cells are formed, which are full of tuber bacteria. These cells, which are full of tuber bacteria, slowly form tumors of various shapes or tubers.

After the bacterium enters the root, the growth of the plant slows down at first. Until the plant produces its working organs, the bacterium lives on its nutrients. It takes about 10-15 days. Then, an interaction and mutual service (mutually beneficial symbiosis) is established between the host plant and its resident bacteria. Carbohy-

drates and other nutrients enter the bacteria from the suckers in the roots of plants, and they are reprocessed in the bacterial cells due to the assimilation of molecular nitrogen from the air and gradually turn into nitrogenous compounds. A part of these compounds is used by the bacteria to provide the body with protein, and a part is excreted in the form of mucus, which the plant uses through these suckers. It was determined that in joint plantings, groundnut tubers are formed 5-6 days earlier than in pure (single) plantings. Here, too, most of the tubers were formed in joint plantings of groundnuts with fast-growing tomatoes. The number of tubers formed in this variant was practically 2 times higher than in pure (single) planting. The mass of tubers in the specified variants was 0.24 grams per plant on average, which is 9.1-100% higher than other phytocenoses (graph 1, table 2).



Graph 1. The number of active tubers in the plant, in numbers (2016-2018 years)

Our results suggest that groundnut co-planting creates more favorable conditions for the formation of a symbiotic apparatus. It can be assumed that the reason for this is that in joint plantings, including in the environment where the roots are fed, the plants have a favorable effect on each other.

Table 2

The state of the symbiotic apparatus at the beginning of the flowering phase of groundnut (2016-2018)

Variants	Number of active tubers, in numbers per plant	Mass of active tubers, in grams per plant	The mass of leghemoglobin in 1 kg of raw tuber, mg/kg
Groundnut (pure sowing)	6,1	0,12	9,6
Groundnut + fast-growing tomato	12,3	0,24	10,8
Groundnut + half fast-growing tomato	10,8	0,18	10,1
Groundnut + half-ripening tomato	11,9	0,22	10,3
Groundnut + potato	12,0	0,21	10,7

The life activity of tuber bacteria is more influenced by soil reaction (pH). In weakly acidic and neutral soils, many large red nodules are formed in the roots of the groundnut plant, which contain a large amount of leghemoglobin. Leghemoglobin has the ability to absorb nitrogen from the air. This is one of the main conditions for the formation of high and quality green mass and seed crop. When the soil pH is 6.0, more than half of the pink tubers are large. At pH of 5.5, tubers are small, pink, at pH of 5.0, tubers are small, dull pink, and more than 50% of tubers do not form at all.

In our experiment, the reaction of the soil solution (pH 5.6-6.2) did not have a limiting effect on the formation of the symbiotic apparatus of groundnut. Thus, it is possible to guarantee the formation of tuberous bacteria in the roots of the groundnut plant in the soils, which are widespread in the Ganja-Gazakh region and whose reaction (acidity, pH) varies from weak to neutral.

One of the factors that significantly influence the formation of the symbiotic apparatus in the groundnut plant is climatic conditions, primarily temperature and water regime. Thus, in 2016, due to the

drop in temperature at the beginning of the groundnut vegetation, 2.8 times less precipitation in May, and sufficient moisture (74 mm) in June, the development of the tubers was quite slow (weak), and their amount was only 5 pieces/plant in pure (single) groundnut plantings, and the mass was 0.11 grams/plant. In joint plantings, the number and mass of tubers was more, and reached the maximum level in the joint planting of groundnut with fast-growing tomatoes.

In joint plantings of groundnut with fast-growing tomatoes, the number of tubers was 12.1pieces/plant, and the mass was 0.25 grams/plant, in joint planting with potatoes, it was 11.9 pieces/plant and 0.22 grams/plant, which is 142.0%, 127% and 138%, 100% more than in pure (single) plantings respectively.

4.2. Plant productivity and product quality. Productivity is the result of the combination of plant growth and development, photosynthetic activity, biomass collection and other aspects of the productivity process in concrete soil and climate conditions and depends on agrotechnical methods. The maximum yield of groundnut seeds in pure planting (2018) was 0.8 t/ha (Fig. 1).

In 2018, with more favorable climatic conditions, among the indicators of the options, the seed yield of groundnut in planting together with fast-growing tomato reached 1.1 tons per hectare, which is 37.5% more than the yield obtained from pure groundnut plantings (0.8 t/ha), and 22.2% more than planting with fast-growing and half early-ripening tomatoes. In 2016 and 2017 with less favorable climatic conditions, the seed yield fluctuated between 0.5-0.8 t/ha. The lowest yield (0.5 t/ha) was obtained from pure groundnut plantings in those years. The increase in groundnut seed yield occurred due to the 27.4% increase in the number of legumes and 156% increase in their mass in joint plantings.

Thus, the most cotyledons were formed in the plantings of groundnuts with fast-ripening tomatoes. In these plantings, the number of cotyledons per plant was 32.1, and the mass was 64.5 grams, which is 27.4% and 155.9% more than in the pure groundnut plantings, respectively (table 3).

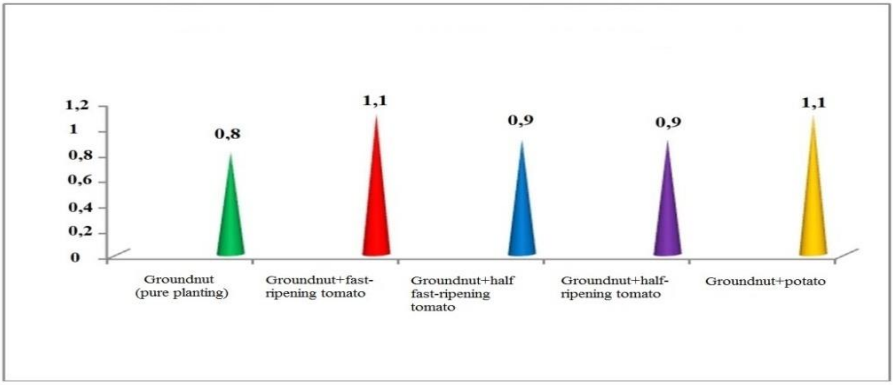


Figure 1. Productivity of groundnut in joint plantings, t/ha (2018)

Table 3

The number and mass of productive (reproductive) organs of groundnut (average for the years 2016-2018)

Variants	The number of cotyle-dons, plant/piece	The mass of legumes, plant/gram	The mass of seed, plant/gram
Groundnut (pure planting)	25,2	25,2	15,2
Groundnut + fast-ripening tomato	32,1	64,5	43,0
Groundnut+ half fast-ripening tomato	29,0	61,8	37,7
Groundnut + half-ripening tomato	28,6	59,7	34,8
Groundnut+ potato	30,0	64,2	40,8

During the use of joint plantings, not only productivity, but also the quality of the obtained product has improved. The oil content of groundnut seeds increased by 2.7% in co-planting with fast-ripening tomatoes compared to pure groundnut planting. A slightly lower percentage of oil was observed in groundnut planting together

with potatoes (49.5%), but the amount of protein decreased in this variant, and this decrease was 2.4-1.5% compared to pure groundnut planting respectively.

4.3. Sowing quality and yield characteristics of groundnut seeds. It is known that the productivity characteristics of seeds are determined by two quality categories. Hereditary traits and acquired traits. Hereditary traits are the natural genetic traits that are passed from the parents of the variety and are passed from generation to generation, while acquired traits are the traits formed as a result of environmental influences on the growing plant. Therefore, yield growth is more influenced by sowing quality of seed and suitability degree for sowing.

The conducted studies allow us to say that groundnut seeds are fundamentally different from each other in terms of their chemical composition and seeding quality. The variant with the lowest mass of 1000 seeds (315 grams) is observed in pure (single) planting of groundnut in Shamkir region. This is 26.7% lower than that of Goranboy district and 13.5-20.8% lower than joint plantings. However, there is no close correlation between seed size and laboratory and field germination abilities. In some cases, groundnut seeds of Goranboy origin showed low field germination capacity (59%), which is 4-26% lower than other variants.

In the end, it can be said that the higher productivity of reproductive organs of groundnut was observed when using the seed material obtained from co-sowing of groundnut with fast-ripening tomatoes. The yield of cotyledons of the specified variant increased to 2 tons per hectare, which is 5.3% higher than other variants and 11.1% higher than the plantings in Goranboy district.

The yield of seeds from cotyledons was 75% in this variant, which is 1.8-3.9% higher than other variants. The amount of oil in the seed reached 52.3%, which was 2.2-5.3% more than other agrocenoses. The amount of protein was slightly lower.

It can be concluded that the groundnut seed characterized by the best productivity indicators is the groundnut seed obtained from sowing together with fast-ripening tomatoes.

4.4. Energetic assessment of agrophytocenoses. In order to achieve an annual increase in agricultural products, more energy must be invested in this field every year. However, the growth of agricultural products is not always adequate to the energy invested. The each technological energy spent on agricultural production must be extracted (paid for). As a rule, all small energy increases are related to crop biomass.

The technological process of agricultural production is evaluated by a system of various indicators. Currently, a more realistic assessment of technological methods is based on energy consumption. Our calculations show that the efficiency of industrial energy when cultivating groundnut in the Western region depends on the composition of agrocenoses. More industrial energy (4.0-4.9 GCol/ha) was in joint planting options, and less in single (pure) groundnut plantings (3.0 GCol/ha). The increase in industrial energy consumption in joint plantings appears to be related to the energy spent on tomatoes and potatoes. The maximum energy yield (11.0 GCol/ha) and energy efficiency coefficient (2.24) with the main production product were ensured during the cultivation of groundnuts together with potatoes.

4.5. Economic efficiency of the experiment. It is important to pay attention to the economic efficiency of this plant along with the study of the cultivation technology of the groundnut plant in the Ganja-Gazakh region. The main goal of our research works is to achieve the cultivation of groundnut samples in farms suitable for the local conditions of this region. The main operating expenses for the cultivation of groundnut under irrigated conditions are the acquisition of seed material (180 x 3 = 540 manats), the application of fertilizers (150 manats in total), plowing (35 manats), harrowing (20 manats), sowing (20 manats). , cultivation (9-10 times one 15 manats, 135-150 manats), harvesting (30 manats), etc. The total cost of expenses is considered to be approximately 945 manats. During the vegetation period, about 260 manats are spent on the implementation of agrotechnical measures, timely watering of the field and irrigation water using manual labor. In general, only 1205-1400 manats are required for the cultivation of groundnut plant in 1 hectare of irrigated land.

The selling price of one centner of groundnuts is 400 manats (300 manats together with cotyledon).

When groundnuts are planted together with fast-ripening tomatoes, the net income per hectare increased to 3100 manats. The cost of one centner of the product was 118.2 manats, and the level of profitability was equal to 238.5%, which is the best indicator among the studied options. In this option (peanuts + early-growing tomatoes) compared to the control (pure (single) planting of peanuts), the net income was 1105 manats more per hectare, and the cost of one centner of the product was 32.4 manats cheaper.

When groundnuts are planted together with fast-ripening tomatoes, the net income per hectare increased to 3100 manats. The cost of one centner of the product was 118.2 manats, and the level of profitability was equal to 238.5%, which is the best indicator among the studied options. In this option (groundnuts + fast-ripening tomatoes) compared to the control (pure (single) planting of groundnuts), the net income was 1105 manats more per hectare, and the cost of one centner of the product was 32.4 manats cheaper.

CONCLUSION

1. As a result of the conducted studies, it was determined that the agro-climatic resources of the Ganja-Gazakh region allow for the effective cultivation of the groundnut plant in this region.
2. The development of the photosynthetic apparatus of groundnut develops from the time of sprouting to seed maturity. The maximum assimilation surface of groundnut leaves (20.2-32.3 thousand m^2/ha) is formed when it is planted together with fast-ripening tomatoes. The leaf surface area of the potato plant increases by 8.2-12.3% in co-planting with groundnut, and by 5.8-19.8% in co-planting with tomato.
3. The correlation coefficient (dependence) between the leaf surface of groundnut and seed yield at the beginning of fruit formation is +0.34±0.39 on average in three years; between photosynthetic potential and seed yield was +0.35±0.38 on average in three years.
4. When groundnuts were planted together with nightshade plants,

tomato infection with phytophthora was reduced by 0.7-29.8%, and potato infection by 32.2-26.2%.

5. The number of weed plants in groundnut joint plantings also decreased in the range of 42.4-51.2% compared to pure (single) planting.
6. When groundnuts are planted together with fast-ripening tomatoes, more favorable conditions are created for the formation of the symbiotic apparatus of legumes (groundnuts). The interaction between the biological activity of the soil and the state of the groundnut symbiotic apparatus reaches on average +0.95±0.04 (number of active tubers) and +0.96±0.035 (mass of active tubers) in three years.
7. The more active functioning of the groundnut symbiotic apparatus is observed in the period from the beginning of flowering to the beginning of fruit formation. In the indicated period, the number of tubers was 38.8-75.1%, and their mass was 14.3-55.6%, and leghemoglobin contained in tubers was in the range of 5.6-22.9%. The correlation coefficient between the amount of leghemoglobin in the tubers and seed yield at the beginning of fruit formation was equal to 0.946±0.059.
8. The maximum seed yield (0.6-1.1 t/ha) with oil content in the range of 49.5-50.2% was formed during co-planting of groundnut with fast-ripening tomatoes and potatoes. In co-planting with groundnut, potato tuber yield increased by 8.1-24.5%, tomato fruit yield increased by 6.2-9.0%, and product quality improved.
9. The maximum energy yield (11.0 GCol/ha) and energy efficiency coefficient (2.24) with the main production product were obtained from the co-planting of groundnut with potatoes.
10. The seed product obtained from co-planting of groundnut with fast-ripening tomato is characterized by better quality indicators. When groundnuts are planted together with fast-ripening tomatoes, the net income per hectare increased to 3100 manats. The cost of one centner of the product was 118.2 manats, and the level of profitability was equal to 238.5%. In this option (groundnut + fast-ripening tomatoe) compared to the control (pure (single)

planting of groundnut), the net income was 1105 manats more per hectare, and the cost price of one centner of the product was 32.4 manats cheaper.

Recommendations for production

1. In the conditions of the Ganja-Gazakh region, it is recommended to plant the groundnut plant together with potatoes and fast-ripening tomatoes. It is recommended to sow 100-120 thousand seeds of groundnut per hectare, 30 thousand/ha of potato tubers, and 35 thousand plants per hectare of tomatoes.
2. The method of planting (sowing) should be wide-row with 70 cm between rows and one plant (groundnut, tomato, potato) should be planted in each row, in plants belonging to the nightshades (tomato, potato), the distance between plants should be 30-35 cm, it is recommended to take a distance of 30-35 cm between nests when planting seeds and to put 5-6 seeds per nest of groundnut.
3. For sowing, it is advisable to use groundnut seeds obtained from planting groundnut together with fast-ripening tomatoes or potatoes.

List of published scientific works related to the dissertation topic

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Address: AZ 1098; Baku, Pirshagi settlement, Sovkhoz №2, Research Institute of Crop Husbandry.

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