KnE Life Sciences

DonAgro
International research conference on Challenges and Advances in Farming, Food Manufacturing, Agricultural Research and Education
Volume 2021

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Conference Paper

Agrobiological Evaluation of Varieties and Methods Used in Growing Garlic in the Forest-Steppe Zone (in the Republic of Ingushetia)

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Abstract

Increasing the production and quality of garlic yield is an important agricultural challenge. In the varying agro-ecological conditions of the North Caucuses, the yield of this crop largely depends on the planting technology and the level of its intensity. Important factors that determine the quality of the garlic yield are the use of varieties adapted to these agro-climatic conditions, high-quality planting materials and agricultural technology that meets the requirements of the crop, and the agro-climatic conditions of the region. At present, the potential productivity of varieties used in the Republic is only 30-40 percent. This is due to the insufficient development of planting technologies that take into account the specific ecological conditions of the region. This study examines the factors regulating the yield and quality of garlic varieties.

Keywords: garlic, fertilizers, planting schemes, variety, planting material, vegetation

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Published: 5 April 2021

Publishing services provided by Knowledge E

Selection and Peer-review under the responsibility of the DonAgro Conference Committee.

1. Introduction

The garlic is one of the oldest vegetable crops. The homeland of garlic is the mountainous and foothill regions of Central Asia. The type of cultivated garlic is divided into two sub-croppers: bolting and common **(**non-bolting). Garlic as one-year crop is sprouted by clovers, as a perennial one - by bulbs. [1].

To grow garlic, the well-fertilized soil, treated to the depth of 25-30 cm, with a neutral reaction of the soil solution (pH 6.1-7.0) is needed. Depending on the agro-climatic conditions of the region, where garlic is grown, a variety of norms and fertilization schemes, agro-technical techniques and planting methods are used [2, 3].Until recently, garlic in our country was grown on small land in farms and in individual gardens. Only

under condition of large-scale farming some individual agricultural enterprises have begun to use areas of several hectares for garlic seeding [4].

An important feature of garlic is its poor adaptation to new agro-climatic conditions. In this connection, varieties and planting technologies that have shown themselves well in one farming zone, brought to another agro-climatic zone, do not adapt well and do not give the expected results [5].

For the successful planting of garlic varieties adapted to the given agro-climatic conditions, high-quality planting material and its pre-sowing preparation are important. Under pre-sowing we mean the crop planting technologies which are in line with the agro-requirements to the crop and the agro-climatic conditions of the region where it is grown [6].

The research is focused on the study of agro-biological characteristics of the tested varieties and on development of the adaptive technology that will be used for growing garlic. In the agro-climatic conditions of the Republic of Ingushetia, no such studies have been carried out, so finding the solution to this issue is becoming quite urgent.

2. Methods and Tools

2.1. Methods

In 2017-2019, in the Republic of Ingushetia, some field experiments were carried out regarding to various garlic varieties planting on the experimental land of the Ingushetia Scientific Institute of Agriculture. The soil of the experimental land is weakly leached medium-thick, medium-loamy chernozems. The thickness of the humus horizon is 46-60 cm. On the lands, the humus content was from 4.80 to 4.90%. Provision with mobile forms of P_2O_5 is 22.5-26.0 mg/kg of soil, with potassium is from 330 to 345 mg/kg. According to agro-physical and agro-chemical properties, the soil is good for growing the tested varieties of garlic. 60 см

During the growing seasons, against the background of air temperatures above the long-term average, there was a lack of moisture in the soil, which was compensated by irrigation of the experimental land.

The purpose of the research is to give the agro-biological evaluation of the tested varieties and improve the elements of the technology used for growing garlic in the forest-steppe zone of the Republic of Ingushetia.

In the course of the research, the following tasks were solved through which we defined:

1. comparative characteristics of the winter and spring varieties of garlic in agro-climatic conditions of the forest-steppe zone of the Ingush Republic.

2. influence of growth stimulants and microfertilizers on growth, development and garlic yield.

3. different schemes used in planting the winter garlic and identified the most optimal for the given region;

4. dependence of yield on various combinations and the time to add the mineral fertilization;

5. optimal time for planting the winter garlic in the forest-steppe zone of the Republic of Ingushetia;

6. efficiency of removing bolters of the winter garlic (bolting one), the variety "Yubileiny-Gribovsky".

2.2. Tools

The object of the research was the garlic varieties: Sochi 56, Ufimsky 22, Chinese spring-planted, Gulliver, Abrek, Yubileiny-Gribovsky, Dagestansky (local), Komsomolets.

3. Results

Our research began with the comparative characteristics of the winter and spring varieties of garlic in agro-climatic conditions of the forest-steppe zone of the Republic of Ingushetia.

The research scheme consists of six experiments and their options:

Experiment 1. Comparative characteristics of three winter and five spring varieties of garlic in the forest-steppe zone of the Republic of Ingushetia.

Experiment 2. Influence of the growth stimulants and micronutrients on growth, development and yield of the spring garlic, the variety "Chinese spring-planted"**.**

Experiment 3. Different planting schemes for growth, development and productivity of the winter garlic, the variety "Yubileiny-Gribovskiy".

Experiment options:

3.1. Four-line pattern (30 + 30 + 30 + 50-8) cm;

3.2. Five-line (20 + 20 + 20 + 20 + 60-8) cm;

3.3. Three-line (60 + 40 + 40-8) cm.

Experiment 4. Dependence of yield on various combinations and the time to add the mineral fertilization.

4.1. Adding the full dose of fertilizers for the main, pre-seeding treatment N90 P100 K110

4.2. Adding P100 to the main soil treatment; N90 K110, when 2-3 leaves are formed;

4.3. Adding P100 to the main soil treatment; N90 K110, when 2-3 leaves are formed; K110 was added at the start a bolting process.

Experiment 5. Optimal time for planting the winter garlic in the forest-steppe zone of the Republic of Ingushetia, the variety "Yubileiny-Gribovsky":

1. October 15;

2. October 30;

3. November 15;

4. November 30.

Experiment 6. Efficiency of removing bolters in the winter bolting garlic, the variety "Yubileiny-Gribovsky".

Common planting techniques were used.

Experiment 1. Comparative characteristics of the garlic varieties. Three varieties of the winter garlic and five varieties of the spring garlic were tested. The winter varieties are Yubileiny-Gribovsky, Dagestansky (local), Komsomolets. The spring-planted varieties are Ufimsky 22, Sochi 56, Gulliver, Abrek, Chinese spring-planted. Recommended planting dates for this zone: planting of the winter varieties on October 15, the spring varieties on April 10 [7, 8].

Table 1: Dynamics of growth of assimilation surface among spring varieties of garlic, cm^2

Measurement date:	**30.04**	**01.05**	**30.05**	**01.06**	**30.06**	**01.07**
Ufimsky 22	196.5	203.6	218.4	226.5	236.5	223.1
Sochi 56	201.4	211.2	221.1	238.3	242.6	237.6
Gullever	244.2	249.3	256.2	283.7	296.4	284.8
Abrek	218.2	223.3	234.1	276.7	279.1	265.4
Chinese spring-planted	249.3	256.1	269.5	282.3	291.2	287.1

Table 2: Dynamics of growth of assimilation surface among spring varieties of garlic, cm^2.

Measurement date	**15.04**	**30.04**	**15.05**	**30.05**	**15.06**
Yubileiny-Gribovsky	21.6	54.6	134.1	290.1	282.4
Dagestan (local)	21.8	72.3	183.6	311.2	293.1
Komsomolets	26.5	84.2	184.1	317.4	304.2

As can be seen from Tables 1 and 2, when seedlings have emerged, the leaf area of the Chinese spring-planted variety was the highest and by June 25, it became the highest in the spring variety "Gulliver". Among the winter varieties, the largest increase in leaf area was observed in Komsomolets variety - 317.4 m,^{2}, and the smallest one was among Yubileiny-Gribovsky variety. By the end of the growing season, with the death of the lower leaves in all studied varieties, their total leaf area also decreases. During the research, the highest yield of the garlic bulbs was obtained in the varieties of the spring garlic – Chinese spring-planted – 15.8 t/ha and Gulliver – 16.2 t/ha, the lowest yield for variety Sochi was 56-10.05 t/ha. Among the winter varieties, the highest yield was observed among Komsomolets variety – 16.7 t/ha, and the lowest one was among Dagestansky (local) variety – 13.9 t/ha [9].

Experiment 2. Influence of growth stimulants and micronutrients on growth, development and yield efficacy of the spring garlic, the variety "Chinese spring-planted".

Experiment options:

1. Control (water);
2. Epin-extra 0.03%;
3. Zircon 0.001%;
4. Terra organic 0.002;
5. Terra organic + Zircon 0.001%.

Soaking was carried out one day before planting for 6 hours after which it was immediately treated with CMC glue and rolled in peat powder [9, 11].

Table 3: Ripening time and yield efficacy of various varieties of the winter and spring garlic, t/ha.

Variety	Yield, t/ha	Bulb weight, gr.	Ripening period
Sochi 56	10.05	20.1	21.06
Ufimsky 22	11.15	22.1	27.06
Chinese spring-planted	15.8	31.6	29.06
Gulliver	16.2	32.5	25.06
Abrek	11.2	23.4	21.06
Yubileiny-Gribovsky	14.5	29.1	16.06
Dagestan (local)	13.9	27.8	22.06
Komsomolets	16.7	33.4	22.06

The influence of pre-sowing treatment of one-clover bulb, as can be seen from Table 4, is quite significant. The yield increase, grown from clovers and treated with the growth regulator Zircon + Terra organic was 4.6 t/ha compared to the control. Also, the treatment of the planting material with the solution of Zircon + Terra organic accelerated the garlic ripening by 9 days compared to the control figure. By the mass of one clover,

Table 4: Economically valuable features evaluation of spring garlic depending on planting material quality.

Options	The number of clovers in a bulb, pcs	Clover's weight, gr.	Bulb weight, gr.	Yield, t/ha	Dry matter content, %	Sugar content, %
Control (water)	8	3.4	28.1	14.1	35.9	21.7
Epin-Extra	9	3.9	35.1	18.45	37.4	23.8
Zircon	8	4.4	35.2	17.6	37.8	24.6
Terra organic	8	3.6	29.2	14.6	36.6	22.4
Zircon + Terra organic	9	4.4	38.4	18.7	38.7	24.9

a variant treated with the solution of Zircon + Terra organic was stood out. The highest content of a dry matter and sugar was also observed in the variants treated with zircon and Zircon + Terra organic.

Experiment 3. Different planting schemes how they impact on growth, development and productivity of the winter garlic, the variety "Yubileiny-Gribovskiy".

The results of our studies applied to three different layouts of garlic plants showed that the mass of leaves, the amount of wet mass of leaves and the average weight of a garlic bulb did not differ significantly depending on the layout of garlic planting [2, 10].

Table 5: Average weight indicators of a bulb, mass of leaves and wet weight of leaves for different schemes of garlic planting in the forest-steppe zone of the Republic of Ingushetia.

Layout	Amount of wet mass per m^2 leaves, kg	Leaves weight, g/dm.	Average weight of one bulb, gr.
Four-line	2.2-2.4	6.4	29.1
Five-line	2.0-2.2	6.2	27.6
Three-line	2.6-2.8	6.4	29.4

Therefore, the layout of the garlic planting does not depend on the biological properties of the garlic variety, rather than on agro-climatic conditions of the region where it grows. The largest leaf mass and bulb weight were observed on a three-line planting scheme, while the ripening time and bulb weight, between the options, did not have some large differences.

Experiment 4. Yield dependence on time when mineral fertilization was added to the winter garlic. Variety "Yubileiny-Gribovsky", fertilization rate in all variants – N90P100K110.

The optimal doses of the mineral fertilizers recommended for our agro-climatic zone are N90P100K110. Analysis of yield efficacy and maturation of underground bulbs showed the significant differences between the period, when the mineral fertilizers were added [9].

TABLE 6: Dependence of yield efficacy on various combinations and time when the mineral fertilization was added.

Fertilization time	Yield, t/ha	Ripening time
1. NPK for basic tillage	14.5	June 16
2. PK for the main tillage N for top dressing.	15.31	June 22
3. P - for the main treatment, N - when 1-2 leaves form, K - at the beginning of bolting.	14.7	June 22

It can be seen from our research that the fractional application of the mineral fertilizers lengthens the growing season of the winter garlic plants and, accordingly, the mass of the bulbs increases. Adding nitrogen fertilizers in early spring is the most productive, due to a decrease in fertilizer losses, by leaching and evaporation in the autumn-winter and winter-spring growing season. The results of the research show that adding potash fertilizers separately during the beginning of the bulb filling is irrational and does not give the expected yield increase.

Experiment 5. Optimal time for planting winter garlic in the forest-steppe zone of the Republic of Ingushetia.

Having analysed the studies of many authors who examined the optimal time for planting the winter garlic in agro-climatic zones that are similar to the forest-steppe zone of the Republic of Ingushetia, we have selected four planting dates for test seeding.

In this experiment, the mineral fertilizers were applied for the main tillage, the planting scheme was four-line pattern (50 + 30 + 30 + 30).

Phenological observations have revealed differences in growth and development of the garlic plant depending on the time of planting. So the leaves of garlic planted in October froze by 1.4-2.6 cm by spring. The leaves of garlic planted in November froze by 0.0-0.6 cm. The ripening dates of the winter garlic in our experiments also varied greatly from June 12 to June 22. The difference in yield, between the first planting on October 15 and the third planting on November 15, was 3.0 t/ha – 26%, while the difference between the first and last planting – 2.2 t/ha – 19.13%. A significant difference was revealed in terms of the amount of wet weight per m^2 of leaves [1, 7, 8]

Thus, after analyzing the data obtained, we can conclude that planting garlic in the early stages leads to a large increase in the green mass of garlic up to 14 cm in the autumn; freezing of leaves up to 2.6 cm; overgrowth of clovers; poor development of the root system and, as a result, a decrease in yield and quality of the bulbs compared to later planting dates – November 15 and 30.

Table 7: Optimal time for planting winter garlic in the forest-steppe zone of the Republic of Ingushetia.

Planting date	15.10	30.10	15.11	30.11
Yield, t/ha	11.5	12.81	14.5	13.7
Ripening time	12.06	12.06	16.06	22.06
The average length of a leaf on 03/10/2018, cm.	12-14	10-11	6-8	2-4
Amount of wet mass per m^2 of leaves, kg	2.0-2.2	2.2-2.4	2.6-2.8	2.5-2.7

Experiment 6. Efficiency of removing bolters of winter garlic (bolting), the variety "Yubileiny-Gribovsky".

During the growing season, after the cessation of growth and the formation of new leaves, a flowering bolter begins to emerge from the axils of the last leaf. After a bolter begins to emerge, the vegetative processes stop, the weight of the above-ground part of the plant begins to decrease, the leaves turn yellow and wilt, the bulb is filled and ripened. At the end of the bolter, the bulbs develop intensively in the capsule, the flowers do not develop and dry out without forming seeds.

Physiological processes in plants with distant flower-bearing bolters pass 6-8 days faster than in plants without removing the peduncles. In plants with removed peduncles, leaves dry out and roots die off 6-8 days earlier than in plants with peduncles. In plants with removed flower-bearing bolters, the bulb mass was 38 g, and the bulb weight with non-removed bolter was 32 g. This is explained by the fact that the root system and the bulb supply the flowering bolter with nutrients by redistributing them from a bulb to a bulb. The weight of the bulbs was 5.5 g, in total with the weight of the bulb is 37.5 g, which is identical to the weight of the bulb with the flower-bearing bolters that were removed.

The bulb yield with removed peduncles was 12.2 t/ha. The bulbs' yield without removing peduncle was 10.4 t/ha. The increase in yield caused by peduncles removing was 1.8 t/ha. But when the peduncles were not removed, we additionally get a healthier planting material – bulbs [10, 12].

4. Discussion

Comparative characteristics of five varieties of the spring garlic showed that the most productive varieties in terms of both yield and bulb weight are Chinese spring-planted (15.2 t/ha and 34.5 g) and Gulliver (15.5 t/ha and 34.5 g). The fastest ripening variety was Abrek. The use of growth regulators and micronutrient fertilizers significantly affects the

increase in the mass of clovers, bulbs and yield in general, as well as early maturity towards a decrease in the growing season. The best result was obtained by processing the planting material with a mixture of Terra organic microbiological fertilizer and Zircon growth stimulator, the yield increase was 1.1 t/ha compared to the control one, while the ripening of the crop accelerated by 9 days, which is also important. In the agro-climatic conditions of the Republic of Igushetia, different planting schemes have an insignificant effect on the duration of the growing season and the bulb size. The yield is influenced by the number of planting places per unit area. Planting garlic in a five-line pattern gives the greatest yield. The results show that fractional application of mineral fertilizers is the most productive. The nitrogen fertilizers adding in the spring reduces the loss of fertilizer by leaching into the ground and evaporation, lengthens the growing season, which increases the mass of the bulb, respectively, the total yield. The increase in yield from the use of fractional fertilization was 1.37 t/ha compared to the control testing. Thus, after analyzing the data obtained, we can conclude that planting garlic in the early stages leads to a large increase in the green mass of garlic up to 14 cm in the autumn; freezing of leaves up to 2.6 cm; overgrowth of clovers; poor development of the root system and, as a result, a decrease in yield and quality of the bulbs compared to later planting dates – November 15 and 30. The results' analysis showed that the physiological processes in plants with removed flowering abolters are 6-8 days faster than in plants where flowering bolters were not removed. The yield increase from flower-bearing bolters accounted to 1.8 t/ha. Thus, we can conclude that the use of this agro-technical method in the forest-steppe zone of the Republic of Ingushetia is economically profitable.

5. Conclusion

For agro-climatic conditions of the Republic of Ingushetia such varieties of the winter and spring garlic as Gulliver, Chinese spring-planted, Komsomolets, Dagestansky (local) are considered to be effective.

The use of growth regulators in a mixture with microbiological fertilizers for processing planting material has a significant effect on increasing the yield of garlic and is ultimately a highly profitable method in the agro-climatic conditions of the Republic of Ingushetia.

For agro-climatic conditions of the Republic of Ingushetia, three- and four-line planting schemes are the most optimal, since they allow maximizing the mechanization of planting, care and harvesting, which will ultimately increase the profitability of garlic production.

For the forest-steppe zone of the Republic of Ingushetia, fractional application of mineral fertilizers is the most productive. The phosphorus and potassium fertilizers adding for the main soil cultivation, and the nitrogen fertilizers for top dressing reduces the loss of nitrogen fertilizers by leaching and evaporation, increases the weight of the bulb and, accordingly, the total yield.

For agro-climatic conditions of the forest-steppe zone of the Republic of Ingushetia, the most optimal time for planting the winter garlic is the first decade of November.

The use of such an agro-technical technique as removing flower-bearing bolters from winter boltering garlic in the conditions of the Republic of Ingushetia is economically profitable.

Funding

These studies were carried out on the basis of the Ingush Scientific Research Institute of Agriculture.

Acknowledgment

We thank our colleagues for their contribution and support in conducting the study. We are also grateful to all the reviewers, who made valuable contributions to the manuscript and helped us to complete the work.

Conflicts of Interest

The authors have no conflicts of interest to declare.

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