Productivity and quality of onion products during the storage depending on mineral nutrition conditions

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Abstract. Onions are eaten fresh throughout the year, so the safety of its products is an important task for production. The quality and safety of products in addition to hereditary characteristics of the variety, are affected by the growing conditions and storage technology, an important role is played by the conditions of the crop mineral nutrition. Studies were carried out in the zone of unstable humidification of the Stavropol Territory in 2016, the storage of products (2016-2017) was carried out in a storage with controlled temperature and ventilation. As a result of researches it is proved that the biggest effect on saving the crop was observed in the application of the estimated rate of the fertilizer N120P170K140 which allowed to reduce the general losses of production of onions in the course of storage in comparison with the control one by 6.5-8.7 %. The use of the calculated rate of fertilizers contributed to the production of the largest amount of dry matter, sugars and vitamin C in the production of onion, and the biochemical parameters of bulbs during storage for all types of the experience have changed.

1. Introduction
The vegetable subcomplex is one of the main and most labor-intensive sectors of agriculture [10]. An important task, along with the development of technologies for the cultivation of agricultural crops is the development of innovative technologies that can reduce to a minimum the loss of products in storage [1, 6, 7]. The quality and safety of fruits, vegetables and potatoes are influenced by hereditary characteristics of the variety, growing conditions and storage technology.
Onion (Allium cepa L.) has a rich biochemical composition, which is why it is a valuable human food product [8, 9]. Onions are used all year round as an important seasoning for food to improve its taste and digestibility, so the preservation of its products is an important task for production.

2. Materials and methods
The aim of the research is to assess the productivity of onions depending on mineral nutrition and analysis of changes in product quality during the storage.
Onions were grown in the zone of unstable moisture of the Stavropol Territory in 2016, the storage of products (2016-2017) was carried out in a warehouse with controlled temperatures and ventilation.
Objects of research: onion Bluster F1, Zeus F1, norms of mineral fertilizers.
Onions were grown as an annual culture by sowing seeds in the soil. The technology of cultivation of the crop was generally accepted for the region [5]. The soil of the experimental site
belong to the ordinary low – humus medium-thick heavy-loamy Chernozem, slightly saline, characterized by dense composition – 1.1-1.2 g/cm³. The soil is characterized by the high absorption capacity, low humus content (3.6 %), average soil nitrification capacity – 28 mg/kg of soil, average mobile phosphorus content – 18-24 mg/kg of soil, increased potassium exchange – 346-355 mg/kg of soil. The content of heavy metals in the soil does not exceed MPC.

The estimated rate of fertilizers for the planned yield of onions in 80 t/ha according to the calculations and the level of soil fertility accounted for N120P170K140 (nitrogen content – 120 kg of active substance per 1 hectare, phosphorus – 170, potassium – 140). Mineral fertilizers were added to the main fertilizer for plowing (60 % of normal – map) and in the structure of fertilizers through drip (potassium nitrate, monopotassium phosphate, ammonium nitrate). The experimental setup to study the effect of fertilizers on the onion productivity and product quality during the storage process included the control (background), the estimated rate under the planned yield and fertilizer rates about settlement with reduced doses of nitrogen, potassium, phosphorus and high dosage of nitrogen:

- Control (background);
- N80P170K140;
- N120P170K140 – calculated dose;
- N120P170K140;
- N120P170K60;
- N180P170K140.

The studies were carried out by two methods: field and laboratory. The experimental setup was built according to the method of organized repetition, the repetition of experiences 3-fold, the placement of plots in the experience of multi-tiered, variants within the repeat – random, the size of a plot at the laying of field experiments – 500 m². Observations, records, calculations and laboratory analyses were carried out according to generally accepted methods and recommendations. Statistical processing of experimental data was carried out by correlation-regression and dispersion methods [4, 11].

The yield of onion in 2016 was placed under storage. Standard onions were stored in bulk. The temperature of the main storage period was 3-4 °C, the humidity was 70-75 %. During the period of storage November-May 2016-2017 each month the selection of product samples for accounting and laboratory analysis was carried out. In assessing the incoming storage products, samples were taken from every third to fifth transport units (sampling rate-not less than 3 % of the mass of the product, when it enters the container - not less than 3 % of the units). A sample from different sample locations within 10% of its mass was taken from the sample for the commodity analysis. 30-50 bulbs (from different places) were selected for chemical analyses.

3. Results and discussion

3.1. Evaluation of productivity and product quality of onion

Mineral nutrition plays an important role in increasing crop yields. Onions, unlike other vegetable crops, are characterized by the low intensity of absorption of nutrients, especially at the beginning of growth. In onions, sown with seeds, the bulb begins to grow about 60 days after germination. By this time the plants have absorbed 10-12 % N, 6-7 % P2O5 and 10 % K2O of the total demand for the growing season. When planting onion sets onion begins to grow after 45 days. At this time, the plants absorb about 10 % N, 3.5 % P2O5 and 8% K2O of the total amount of nutrients in the crop [3].

Studies have shown that the application of fertilizers increased the yield of onions. The calculated rate of fertilizers N120P170K140 for onions in the experiment was focused on obtaining a yield of 80 t/ha. Under favorable conditions of nutrition and when using irrigation, onions can form high yields of products that can be kept for a long time.

Drip irrigation of onions without fertilizers (control) showed the lowest yield in the
experiment – 73.0 t/ha (Bluster F1) and 77.0 (Zeus F1) and the lowest marketability of bulbs – 88.7 and 90.5 %, respectively. Among the studied doses of fertilizers, the lowest yield of onions was observed when applying a reduced rate of nitrogen fertilizer and was less than other doses by 1.6-11.6 %, which indicates a high role of nitrogen in the mineral nutrition of the crop. The highest yield of onions was obtained by applying an increased dose of nitrogen fertilizers, the difference compared to the control was 12.2-14.7 t/ha. The use of the calculated rate of fertilizers (N120P170K140) contributed to the yield of onions exceeding the control variant by 10.2 t/ha, with such a balanced mineral nutrition, the maximum marketability of bulbs in the experiment was ensured – 95.8-96.5 %, which was higher relative to the control by 5.3-7.5 %. The least marketability of bulbs among the studied doses of fertilizer were obtained when using low amounts of potassium (N120P170K60) relative calculated fertilizer norms – of 89.4-90.7 %. Among the studied hybrids of onions, the highest yield was obtained from onions Zeus F1, the indicators depending on the variant of the experiment were higher with respect to the Bluster F1 by 3.7-8.0 t/ha (table 1).

**Table 1. Effect of fertilizers on the productivity of onion.**

| Type                  | Yield t/ha | Marketable product, % | Diseased and damaged bulbs, % |
|-----------------------|------------|-----------------------|--------------------------------|
| **Bluster F1**        |            |                       |                                |
| Control (background)  | 73.0       | 90.5                  | 6.7                            |
| N80P170K140           | 75.5       | 91.3                  | 4.1                            |
| N120P170K140          | 83.2       | 95.8                  | 2.0                            |
| N120P120K140          | 77.1       | 92.7                  | 4.1                            |
| N120P170K60           | 80.7       | 90.7                  | 8.5                            |
| N180P170K140          | 85.2       | 91.1                  | 8.8                            |
| LSD 05                | 1.6        | 0.4                   | 1.4                            |
| **Zeus F1**           |            |                       |                                |
| Control (background)  | 77.0       | 88.7                  | 8.5                            |
| N80P170K140           | 80.1       | 91.2                  | 6.3                            |
| N120P170K140          | 87.2       | 96.5                  | 2.4                            |
| N120P120K140          | 85.1       | 91.8                  | 3.5                            |
| N120P170K60           | 84.4       | 89.4                  | 4.8                            |
| N180P170K140          | 91.7       | 95.0                  | 9.5                            |
| LSD 05                | 2.1        | 10.8                  | 1.2                            |

* LSD05 – the least significant difference for a 5 % significance level

When harvesting onions, damaged and diseased bulbs were rejected. Bulbs affected by diseases, with cuts, indentation, hidden and obvious mechanical damage, which are formed during cleaning, transportation, loading, unloading and sorting, are not suitable for long-term storage. Further parasitic and non-parasitic damage, increased evaporation, breathing, fading, increased weight loss arises in the damaged follicles.

When using an increased dose of nitrogen fertilizers, the weakest and damaged bulbs were obtained – 8.8-9.5 %; when feeding with an excess amount of nitrogen by increasing the water content of cells, susceptibility to diseases and the degree of their development in crops increases. Application of calculated doses of fertilizers (N120P170K140) contributed to obtaining the lowest number of sick and damaged bulbs in the experiment, and the figure was smaller in comparison with other variants 2.1 to 7.1 %.

**3.2. Assessment of the quality of onion products during the storage**

The varieties of onion Bluster F1 and Zeus F1 belong to the Peninsula types of onions, which under optimal storage conditions can be stored for a long time. An important tool of influence on the keeping
quality of onions is the mineral nutrition.

At the beginning and at the end of storage dry matter content and biochemical composition of bulbs were analyzed. The biochemical composition of onion production changed during the storage period.

The main chemical indicator of onions is the dry matter content in the juicy scales of bulbs. There is a direct relationship between the content of dry matter and the keeping quality of onions: the richer the bulb dry matter, the better it will remain in the cold period. During the storage, the amount of dry matter in the bulbs increased due to the loss of moisture in the product by 0.8-1.3 %. Most dry matter accumulated in products grown with the use of fertilizers, with the least amount of dry matter noted when applying nitrogen in the fertilizer system at a dose of 180 kg d. v. (table 2).

Table 2. Effect of fertilizers on dry matter content and biochemical composition of onion during storage.

| Type       | Dry matter, % at the beginning of storage | Sugars, % at the beginning of storage | Vitamin C, mg % at the beginning of storage | Nitrates, mg/kg at the beginning of storage |
|------------|-------------------------------------------|--------------------------------------|-------------------------------------------|--------------------------------------------|
|            | at the end of storage                     | at the end of storage               | at the end of storage                     | at the end of storage                      |
|            |                                           |                                       |                                           |                                            |
| Bluster F1 |                                           |                                       |                                           |                                            |
| Control    | 13.4                                      | 14.5                                 | 7.05                                      | 7.37                                       | 8.7                                       | 7.2                                       | 32                                        | 10                                         |
| (background)|                                           |                                       |                                           |                                            |                                           |                                           |                                            |                                            |
| N108P170K140 | 14.0                                     | 15.3                                 | 7.27                                      | 7.61                                       | 10.4                                      | 8.7                                       | 40                                        | 13                                         |
| N120P170K140 | 15.7                                     | 16.5                                 | 7.83                                      | 8.13                                       | 12.2                                      | 10.8                                      | 45                                        | 17                                         |
| N120P120K140 | 14.8                                     | 15.8                                 | 7.71                                      | 8.07                                       | 11.7                                      | 10.1                                      | 53                                        | 23                                         |
| N120P170K60 | 14.3                                     | 15.3                                 | 7.50                                      | 7.85                                       | 11.2                                      | 9.7                                       | 60                                        | 25                                         |
| N180P170K140 | 12.3                                     | 13.1                                 | 6.95                                      | 7.31                                       | 8.3                                       | 7.0                                       | 85                                        | 44                                         |
| LSD05      | 0.4                                       | 0.3                                  | 0.11                                      | 0.20                                       | 0.3                                       | 0.3                                       | 3                                         | 3                                          |
| Zeus F1    |                                           |                                       |                                           |                                            |                                           |                                           |                                            |                                            |
| Control    | 8.2                                       | 9.1                                  | 6.85                                      | 7.15                                       | 7.7                                       | 6.3                                       | 61                                        | 23                                         |
| (background)|                                           |                                       |                                           |                                            |                                           |                                           |                                            |                                            |
| N108P170K140 | 9.4                                      | 10.5                                 | 7.05                                      | 7.33                                       | 8.0                                       | 6.5                                       | 70                                        | 33                                         |
| N120P170K140 | 14.0                                     | 15.1                                 | 7.63                                      | 7.94                                       | 10.5                                      | 9.1                                       | 74                                        | 38                                         |
| N120P120K140 | 13.3                                     | 14.4                                 | 7.48                                      | 7.80                                       | 9.8                                       | 8.2                                       | 77                                        | 41                                         |
| N120P170K60 | 13.1                                     | 14.2                                 | 7.35                                      | 7.67                                       | 9.0                                       | 7.4                                       | 80                                        | 48                                         |
| N180P170K140 | 8.7                                      | 9.7                                  | 6.55                                      | 6.87                                       | 6.7                                       | 5.3                                       | 115                                       | 70                                         |
| LSD05      | 0.3                                       | 0.5                                  | 0.14                                      | 0.12                                       | 0.4                                       | 0.2                                       | 2                                         | 8                                          |

The carbohydrates in the onion bulb is mainly represented by sugars. Among the sugars there is sucrose, fructose and maltose. In experimental samples the sugar content in the beginning of storage was in the range of 6.55-7.83 %, by the end of the store increased by 22 to 45 mg/kg. Dynamics of accumulation of sugars, depending on the applied doses of fertilizer was the same as in the determination of dry substance: more total sugars accumulate when using the estimated rate of fertilizer (N120P170K140) and by the end of storage made up 6.87 % (Bluster F1) and 7.31 % (Zeus F1).

Onions contain large amounts of various vitamins. Most onions contain vitamin C. Studies have found that when storing onions, the amount of vitamin C in the product decreased by 1.3-1.7 mg % depending on the hybrid and the variant of experience. The highest content of vitamin C was obtained by applying the calculated rate of fertilizers (N120P170K140): 10.5-12.2 mg % at
the beginning of storage and 7.7-10.8 mg % - at the end of storage.

The maximum permitted concentration of nitrates in onions is 80 mg/kg. The results showed that the number of nitrates in the samples of onions was within the norm, except for the variant of the experiment, when an increased dose of nitrogen in the fertilizer system was used. During the storage of onions as a result of cleavage in the production of complex compounds, the nitrate content decreased by 22-45 mg/kg, by the end of storage was 10-70 mg/kg, the least amount of nitrates was obtained in the control version (background).

The biochemical composition of onion differed between the studied hybrids. Most of the solids, sugars and vitamin C was in the production of Bluster F1 and indicators were higher than Zeus F1 by 1.1-5.4 %, 0.15-0.44 % and 0.9-2.4 mg %, respectively. The least amount of nitrates accumulated in the production of Bluster F1 and was less than in Zeus F1 by 13-30 mg/kg.

3.3. Estimation of losses of onion during the storage

The main reasons for the loss of onions during storage-natural loss and losses associated with diseases of the bulbs and their germination. Mineral nutrition of the crop has a great influence on the safety of vegetable products during storage.

Natural loss occurs as a result of the processes of respiration and evaporation of moisture from the product. Studies have shown that the natural mass loss was observed in all samples of onions. The best storability was observed in onion grown with the application of balanced rate of fertilizers (calculated dose N120P170K140): natural losses during storage have Bluster F1 was 2.8 %, Zeus, F1 – 2.5 %, which was lower compared with control and other fertilization rates of 0.3 and 1.1 %. The greatest losses in the mass of bulbs due to natural loss were observed when using a culture of increased dose of nitrogen (N120P170K140) in mineral nutrition, the difference with respect to control and other variants of the experiment constituted 0.2-1.6 %. Natural loss of samples of onions Zeus F1 was less compared to the Bluster F1 0.3-0.4 % (table 3).

### Table 3. Influence of fertilizers on quantitative losses of onions during storage.

| Type       | Natural losses, % | Quantitative losses | Sick bulbs, % | Total losses, % | +/- over control, % |
|------------|------------------|---------------------|---------------|-----------------|-------------------|
|            | Bluster F1       |                     |               |                 |                   |
| Control    | 3.6              | 1.7                 | 7.5           | 12.8            |                   |
| (background) |                  |                     |               |                 |                   |
| N80P170K140 | 3.3              | 2.0                 | 5.8           | 11.1            | -1.1              |
| N120P170K140 | 2.8              | 1.1                 | 2.5           | 6.4             | -6.4              |
| N120P120K140 | 3.3              | 2.4                 | 3.0           | 8.7             | -8.7              |
| N120P170K60  | 3.2              | 1.5                 | 6.7           | 11.4            | -1.4              |
| N180P170K140 | 3.8              | 3.7                 | 8.0           | 15.5            | 2.7               |
| LSD 05     | 0.1              | 0.2                 | 0.2           | 0.4             |                   |
| Zeus F1    | 3.2              | 1.6                 | 6.5           | 11.3            |                   |
| (background) |                  |                     |               |                 |                   |
| N80P170K140 | 3.0              | 1.8                 | 3.8           | 8.6             | -2.7              |
| N120P170K140 | 2.5              | 0.9                 | 1.4           | 4.8             | -6.5              |
| N120P120K60  | 2.8              | 2.2                 | 2.0           | 7.0             | -4.0              |
| N120P170K60  | 3.1              | 1.3                 | 4.7           | 9.1             | -2.3              |
| N180P170K140 | 3.6              | 3.3                 | 7.5           | 14.4            | 3.1               |
| LSD 05     | 0.2              | 0.2                 | 0.2           | 0.3             |                   |

During the storage of onions bulb, the germination of bulbs was observed. The reason for the
germination of onions is often unbalanced mineral nutrition during cultivation or the introduction of high doses of nitrogen, potassium or phosphorus fertilizers, which subsequently leads to increased growth processes and the accumulation of nitrates in the product.

When studying the effect of mineral nutrition on the germination of onions during storage, it was noted that the smallest number of sprouted bulbs was noted in the application of the calculated rate of fertilizers – 0.9-1.1 %, which appeared to be less than the control by 0.6-1.7 %. Most of all, the germination of onions during storage with high nitrogen nutrition of plants was activated, as a result, the number of sprouted bulbs was higher in relation to the use of the calculated norm of fertilizers in Bluster F1 by 2.6 %, Zeus F1 – by 2.4 %. The greatest resistance to germination showed onions Zeus F1, in which the difference in the number of sprouted bulbs compared to the Bluster F1 was 0.1-0.4 %.

The most important factor determining the suitability of onions for long – term storage is the infectious background of the product, the contamination of its pathogens with fungal, bacterial, mycoplasma and viral diseases, as well as pests. The onion, which looks healthy after harvesting, can keep the infection in the bulbs, which then manifests itself in the process of storage [2]. The manifestation of infection is affected by the level of mineral nutrition of plants during cultivation.

In the initial period of storage of sick bulbs from the total number was more than in subsequent periods, as the reduced storage temperature suppresses the development of diseases. The least number of infected onion was observed when applying the estimated rate of fertilizer: the figure for the variety Bluster F1 was higher than in controls and while using \( N_{60}P_{170}K_{140} \), \( N_{120}P_{120}K_{140} \), \( N_{150}P_{170}K_{140} \) or \( N_{180}P_{170}K_{140} \) for 0.5-5.5 %, Zeus F1 – 0.6-5.9 %. Most of the diseases were manifested in products grown with the use of increased norms of nitrogen fertilizers and in the control – 6.5-8.0 %, which was higher than in the application of the calculated norm by 4.1-6.1 %. The number of infected bulbs in the hybrid Bluster F1 exceeded Zeus F1 by 0.5-2.0 %.

The total losses of onions during storage, depending on the type of the experiment, amounted to 4.8-15.5 %. The loss of production of onion bulb with the application of fertilizers during storage was lower than in control by 1.4-8.7 %, with the exception of variant \( N_{60}P_{170}K_{140} \) where the figure was higher compared to control 2.7 and 3.1 %. The lowest loss of onion production was noted as a result of the application of the calculated rate of fertilizers (\( N_{180}P_{170}K_{140} \)) – the indicator was lower in relation to other type of experiment by 2.2-9.6 %.

4. Conclusion

These experiment’s data show that mineral nutrition of onions during the cultivation plays an important role in the course of biochemical, physiological and microbiological processes during storage. Studies have found that as a result of the use in the technology of growing onions, an increased dose of nitrogen in the nutrition system (\( N_{180}P_{170}K_{140} \)), along with the highest yield, the sickest and damaged bulbs in the experiment were obtained, the indicators exceeded the control by 12.2-14.7 t/ha and 1.0-2.1 %, respectively.

The use of the calculated rate of fertilizers (\( N_{120}P_{170}K_{140} \)) contributed to the yield of onions, which was greater in relation to the control type by 10.2 t/ha, with such a balanced mineral nutrition, the maximum marketability of products in the experiment was ensured – 95.8-96.5 %.

The analysis of the effect of mineral nutrition of onion on the change of biochemical parameters by the end of the storage period showed that the content of dry matter and sugars increased by 0.8-1.3 % and 0.28-0.36 %, respectively, the content of vitamin C decreased by 1.3-1.7 mg %, nitrates – 22-45 mg/kg.

As a result of the research it is established that the best storability of onion is manifested in the use of fertilizer estimated rate (\( N_{120}P_{170}K_{140} \)): the total loss of production appeared to be the lowest in the experiment - was lower in relation to other variants of 2.2 and 9.6 %.

References
[1] Andreev Y M 2002 Vegetable-growing (Moscow: Profbrizdat)
[2] Borisov V A and Litvinov A V 2003 Quality and keeping quality of vegetables (Moscow: GNU
VNIIO)

[3] Deryugin I P and Kulyukin A N 1998 *Nutrition and fertilizers for vegetable and fruit crops* (Moscow: Publishing House of Moscow Agricultural Academy)

[4] Dospekhov B A 1985 *Technique of field experience* (Moscow: Kolos)

[5] Dubinin S V and Osikhov A I Technology of cultivation of onions *Potatoes and Vegetables* 2 20

[6] Galani J H Y, Patel J S, Patel N J and Talati J G 2017 Storage of fruits and vegetables in refrigerator increases their phenolic acids but decreases the total phenolics, anthocyanins and vitamin C with subsequent loss of their antioxidant capacity *Antioxidants* 6 59

[7] Gish R A and Gikalo G C 2012 *Vegetable-growing in the South of Russia* (Krasnodar: Publishing house "EDVI")

[8] Ibragimova M G and Khovrin A N 2016 Promising onion hybrid *Potatoes and Vegetables* 7 39-40

[9] Khovrin A N and Monakhos G F 2014 Production and selection of onions in Russia *Potatoes and Vegetables* 7 18-21

[10] Selivanova M V, Sigida M S, Esaulko N A, Aysanov T S and Barabash I P 2016 The use of biologically active substances at cultivation of cucumber *Research Journal of Pharmaceutical* 7(4) 1720-6

[11] Tumanyan A F, Shcherbakova N A, Tusaint F, Seliverstova A P and Tyutyuma N V 2019 Heavy Metal Contents in Soils and Vegetables of Southern Russia *Chemistry and Technology of Fuels and Oils* 54 766-70