Resource-saving elements in onions growing technology on Nizhjeje Povolzhje region irrigated lands

N I Matveeva¹, V P Zvolinsky¹, N Yu Petrov² and V A Zaitsev²

¹Federal State Budgetary Scientific Institution "Caspian Agrarian Federal Scientific Center of the Russian Academy of Sciences", 8 Severny Square, Salty Zaymishche village, Chernoyarsk district, Astrakhan region, 416251, Russia
²Volgograd State Agrarian University, 26 University Avenue, Volgograd, 400002, Russia

E-mail: matni29@mail.ru

Abstract. The aim of this work was to prove many years research (at least two rotations) devoted to the problems of onion growing for industrial purposes on Nizhneje Povolzhje irrigated land. For these purposes, we have selected two farms with typical characteristics and production conditions in Astrakhan and Volgograd regions. During the period of the first rotation (2011-2015), we conducted competitive tests for the number of onion varieties and hybrids introduction and adaptation, as the result of which the zoned variety Volgodonets was selected for the second rotation (2016-2020) as a control and two regionalized hybrids of foreign selection Pandero F₁ and Benefit F₁. These samples were sown in the selected experimental plots as part of five-field vegetable-grain crop rotations in both farms. As the result, over five years of observations, the Benefit F₁ hybrid showed the highest yield of 150.16 t/ha, Pandero F₁ - 139.58 t/ha, and the Volgodonets variety - only 69.35 t/ha in Astrakhan region and 129.57 t/ha; 103.10 t/ha; 74.00 t/ha, respectively, in Volgograd region. The highest profitability indicator was provided by the Benefit F₁ hybrid, which amounted to 87.94%.

1. Introduction
On the irrigated lands of the Nizhneje Povolzhje region onions has long been grown, both for their own consumption and sale outside the region [1, 2, 3, 4]. In the late 20th and early 21st century a well-deserved leadership in the production of this valuable vegetable crops kept by the growers of the Volgograd and Astrakhan regions [5, 6, 7]. At the same time, irrigation of plantations is mainly carried out at the expense of the Volga water, since in recent decades the low-water Don has lost its strategic importance in the irrigation of agricultural lands in the south of the Volgograd region. In recent years, the Volgograd region produces 350.0...355.0 thousand tons of onions per year, and the Astrakhan region - 278.0...280.0 thousand tons, respectively. To be objective we will consider not only gross production, but also the number of goods per capita. And here the situation is somewhat different [8, 9, 10].

In the Astrakhan region, the production of onion is 275.0...278.0 kilograms per inhabitant per year, and in the Volgograd region it is 140.0...142.0 kg. At the same time, it should be noted that this is many times higher than the norms of the "food basket", according to which the annual consumption is 28.4 kg/year per average consumer. That is, onion production in the Astrakhan region exceeds the consumption rate by 9.0...9.8 times, and in the Volgograd region - by 4.0...4.9 times [11, 12]. This
indisputable fact encourages the commodity producer, and in reality the farmer and the shareholder, to enter the market with the surplus of their goods. Market relations, ultimately, are based on the main conditions – whether there is profit from the product or not. In the first case, the most important market law is implemented: commodity-money-commodity, and in the second-the market process may not even begin.

2. Materials and methods
For the onion growing effectiveness scientific substantiation and the search for resource-saving elements in technological processes under irrigation conditions in the Nizhneje Povolzhie region, we laid scientific experiments in the land use of farms in the Caspian lowland and the Ergeninskaya Upland. To increase the reliability of the experiments, typical and medium-sized farms were selected with many years of experience in onion growing for the markets of Russian regions. The first is located in the Chernoyarsk district of the Astrakhan region on the lands of the farmer O. V. Zvolinsky, who has a vegetable-grain crop rotation on an area of 152 hectares of light chestnut soils, including with an annual placement of onions on the area of 30 hectares. The specified area is represented by slightly saline soils with independent irrigation from the Volga River. The second plot is in the Gorodishchensky district of the Volgograd region on the lands of the farmer V. A. Zaitsev, which has a significantly larger land use, including also a vegetable-grain crop rotation with the area of 158 hectares, including 30 hectares of onion annually. Chestnut soils are not saline.

The experiments were laid in 2011 and were carried out up to and including 2020. Vegetable grain rotations are five-field rotations, so in both cases two full rotations were performed. According to the program of experiments, the first rotation was the introduction and adaptation of the most productive varieties and hybrids for cultivation, in one case, on the light chestnut soils of the Caspian lowland, and in the other, on the chestnut soils of the Ergeninskaya Upland. The second rotation was characterized by the fact that multifactorial experiments were carried out with the following tasks: factor A - selection of optimal varieties and hybrids for commercial production; factor B - the search for optimal seeding rates for onions in the developing soil-climatic and technological conditions; factor D - optimization of vegetation irrigation rates and seasonal irrigation rates; factor C - optimization of mineral nutrition levels. The main condition for the experiments was to obtain the highest yield while optimizing resource costs and observing sanitary standards for the quality of the grown products. The experiments were carried out in full and we provided the final indicators for production, costs and work efficiency for the second rotation, that is, 2016-2020. These indicators are average annual for the last 5 years.

For the processing of samples and experimental field plots, we used B. A. Dospekhov’s field-plot technique [13], as well as scientific publications of Russian scientists on the topic under discussion.

3. Results and discussion
Let us consider the sequentially presented material, which reflects the costs and production per 1 ha of arable land (Table 1). From Table 1 it follows that in both experiments there is a significant saturation, both with fixed and circulating assets, which range from 725.4 thousand RUB/ha in the Gorodishchensky district to 812.8 thousand RUB/ha in the Chernoyarsk district. Electricity consumption per unit area in the Chernoyarsk district is significantly higher than in Gorodishchensky one and amounts to 5522.50 kW/h/ha versus 4147.67 kW/h/ha. The indicators for the power-to-weight ratio vary, both for one hectare and for one worker. There is a significant difference, both in the technologies for applying mineral fertilizers and in their volumes. In total, under the conditions of 80% minimum moisture capacity and the application of fertilizers corresponding to option I, the amount of costs per hectare was 531078.00 RUB in the Chernoyarsk district and 484752.00 RUB - in Gorodishchensky one. With the decrease in minimum moisture capacity to 75% and application of fertilizers according to option II, the costs amounted to 524794.75 RUB/ha and 477718.95 RUB/ha, respectively. The cost reduction in option II is due to the decrease in irrigation water volumes by 1440.70 RUB/ha in the Chernoyarsk district and 1213.45 RUB/ha - in the Gorodishchensky district, as well as the decrease in NPK application by 4842.55 RUB/ha and 5819.60 RUB/ha, respectively.
With the decrease in minimum moisture capacity to 70% and the application of fertilizers according to option III, the cost rate amounted to 518511.74 RUB/ha in the Chernoyarsk district and 470685.90 RUB/ha in the Gorodishchensky one, as well as the decrease in NPK application in the amount of 9685.11 RUB/ha and 11639.20 RUB/ha respectively. The selling prices of manufactured products also vary. So, in the Chernoyarsk district, the farmer Zvolinsky O.V. on average for 5 years sold onions at the price of 6647.00 RUB/t, and in Gorodishchensky district the farmer V.A. Zaitsev sold onions for 6140.00 RUB/t. This can be explained by only one circumstance, the products of the farm Zvolinsky O.V. in the Chernoyarsk district had a higher quality and purchasing power at manual packing than the products of the farmer V.A. Zaitsev in the Gorodishchensky district, which were packed by using the "combine" method.

Table 1. Main indicators of the experiments carried out for 2016-2020.

| No. | Item                                      | Unit of measurement     | Indicator                  | Chernoyarsk district | Gorodischensky district |
|-----|-------------------------------------------|-------------------------|----------------------------|----------------------|-------------------------|
| 1   | Fixed assets                              | RUB/ha                  | 520070.27                 | 441906.06            |
| 2   | Working capital                           | RUB/ha                  | 292760.20                 | 283476.97            |
| 3   | Funding                                   | RUB/ha                  | 812830.47                 | 725383.03            |
| 4   | Power consumption                         | kW/h/ha                 | 5522.50                   | 4147.67              |
| 5   | Power consumption                         | RUB/ha                  | 28814.90                  | 24269.03             |
| 6   | Energy-to-weight ratio                    | kW/h/ha                 | 20.4                      | 28.9                 |
| 7   | Power-to-weight ratio of 1 worker         | kW/h/person             | 17.5                      | 31.0                 |
| 8   | The costs of mineral fertilizers          | kg active material/ha   | 938.0                     | 1446.0               |
| 9   | The costs of mineral fertilizers          | RUB/ha                  | 96851.10                  | 116392.07            |
| 10  | Total costs per unit of arable land at 80% minimum water capacity | RUB/ha                  | 531078.00                 | 484752.00            |
| 11  | Costs per unit of arable land at 75% minimum water capacity | RUB/ha | - 1440.70 (H₂O) | - 1213.45 (H₂O) |
|     |                                           |                         |                            |                      |
|     |                                           |                         | - 4842.55 (NPK)           | - 5819.60 (NPK)      |
| 12  | Costs per unit of arable land at 70% minimum water capacity | RUB/ha                  | 524794.75                 | 477718.95            |
|     |                                           |                         |                            |                      |
|     |                                           |                         | - 2881.15 (H₂O)           | - 2426.90 (H₂O)      |
|     |                                           |                         | - 9685.11 (NPK)           | - 11639.20 (NPK)     |
| 13  | Average seasonal price                    | RUB/t                   | 6647.00                   | 470685.90            |

As follows from Table 2, the decrease in minimum water capacity from 80% to 75% and even more to 70%, which also causes a proportional reduction in the levels of mineral nutrition calculated for options II and III, entails a significant loss of yield, which in turn affects the obtained products cost which is presented in Table 3.
Table 2. Productivity by variants of the conducted experiments for 2016-2020.

| Option | Chernoyarsk district | Gorodischensky district |
|--------|----------------------|-------------------------|
|        | Minimum water capacity | NPK etc. | Variety, hybrid | Minimum water capacity | NPK etc. | Variety, hybrid |
| I      | 80% | N - 560 Volgodonets | 69.35 | P - 206 Pandero F1 | 139.58 | N - 326 Volgodonets | 74.00 |
|        |     | K - 206 Benefit F1 | 150.16 | P - 570 Pandero F1 | 103.10 | K - 550 Benefit F1 | 129.57 |
| II     | 75% | N - 490 Volgodonets | 60.62 | P - 197 Pandero F1 | 125.82 | N - 305 Volgodonets | 69.93 |
|        |     | K - 197 Benefit F1 | 137.09 | P - 570 Pandero F1 | 100.47 | K - 550 Benefit F1 | 122.47 |
| III    | 70% | N - 456 Volgodonets | 53.71 | P - 188 Pandero F1 | 109.02 | N - 285 Volgodonets | 68.07 |
|        |     | K - 188 Benefit F1 | 112.59 | P - 570 Pandero F1 | 98.50 | K - 550 Benefit F1 | 117.02 |

Table 3. Received products for 2016-2020, RUB.

| Option | Chernoyarsk district | Gorodischensky district |
|--------|----------------------|-------------------------|
|        | Variety, hybrid | Yield, t/ha | Price, RUB/t | Amount, RUB | Variety, hybrid | Yield, t/ha | Price, RUB/t | Amount, RUB |
| I      | Volgodonets | 69.35 | 6647 | 469096.45 | Volgodonets | 74.00 | 6140 | 454360.00 |
|        | Pandero F1 | 139.58 | 6647 | 927788.26 | Pandero F1 | 103.10 | 6140 | 633034.00 |
|        | Benefit F1 | 150.16 | 6647 | 998113.52 | Benefit F1 | 129.57 | 6140 | 795559.80 |
| II     | Volgodonets | 60.62 | 6647 | 402941.14 | Volgodonets | 69.93 | 6140 | 429370.20 |
|        | Pandero F1 | 125.82 | 6647 | 836325.54 | Pandero F1 | 100.47 | 6140 | 616885.80 |
|        | Benefit F1 | 137.09 | 6647 | 911237.23 | Benefit F1 | 122.47 | 6140 | 715965.80 |
| III    | Volgodonets | 53.71 | 6647 | 357010.37 | Volgodonets | 68.07 | 6140 | 417949.80 |
|        | Pandero F1 | 109.02 | 6647 | 724655.94 | Pandero F1 | 98.50 | 6140 | 604790.00 |
|        | Benefit F1 | 112.59 | 6647 | 748385.73 | Benefit F1 | 117.02 | 6140 | 718502.80 |

We reflected the decrease in the efficiency of vegetable growers due to the reduction in irrigation rates and doses of mineral nutrition of plants in Table 3. A simple analysis shows that the cost reduction for option III in the amount of 12566.26 RUB/t resulted in the loss in the cost of marketable products for the Pandero F1 hybrid in the amount of 203132.32 RUB/t, and for the Benefit F1 hybrid - 245727 RUB/t. In fact, they saved a ruble, but lost twenty rubles on the example of the Chernoyarsk district. The situation is similar in the Gorodischensky district: while saving 14066.10 RUB/t, we lose 28240.00 RUB/t. That is, the losses are 2 times higher than the apparent savings. And, as a consequence, the results of production activities are appropriately reflected in the financial indicators, which are presented in Table 4.

By analyzing the data in Table 4, we note that due to its low yield, the Volgodonets variety, which we took in the experiments for control, although it shows quite a decent yield over the years of research, so in the Chernoyarsk district it showed a yield of 69.35 t/ha, and in the Gorodischensky district the yield was even 74.00 t/ha, but all this is not enough with highly costly technologies and, as the result, in all the variants of the experiment, the production of the Volgodonets variety onion is unprofitable. The production of hybrids Pandero F1 and Benefit F1 is profitable in all the variants of the experiment, but it is quite obvious that both in the Chernoyarsk and in the Gorodischensky districts, vegetable growers will give preference to the Benefit F1 hybrid grown according to option I, which provided the highest yield and the largest amount of revenue for products and, as the result, maximum profit. The indicators of onion production efficiency are shown in Table 5.
Table 4. Financial results for 2016-2020.

| Option | Variety, hybrid | Chernoyarsk district | Gorodishchensky district |
|--------|-----------------|-----------------------|--------------------------|
|        | Costs, RUB | Revenue, RUB | Profit, RUB | Costs, RUB | Revenue, RUB | Profit, RUB |
| I      | Volgodonets | 460969.45 | - 70108.55 | 484752.00 | 633034.00 | 148282.00 |
|        | Pandero F₁ | 927788.26 | 396710.26 | 795555.80 | 310803.80 |
|        | Benefit F₁ | 988113.52 | 467035.52 | 374854.52 | 310803.80 |
| II     | Volgodonets | 402941.14 | - 121853.61 | 477718.95 | 139166.85 | 274246.85 |
|        | Pandero F₁ | 836325.54 | 311530.79 | 751965.80 | 274246.85 |
|        | Benefit F₁ | 911237.23 | 386442.48 | 751965.80 | 274246.85 |
| III    | Volgodonets | 557010.37 | - 161501.37 | 417949.80 | 52119.10 |
|        | Pandero F₁ | 724655.94 | 206144.20 | 604790.00 | 134721.10 |
|        | Benefit F₁ | 748385.73 | 229873.99 | 718502.80 | 248433.90 |

Table 5. Production efficiency onions for 2016-2020.

| Option | Variety, hybrid | Chernoyarsk district | Gorodishchensky district |
|--------|-----------------|-----------------------|--------------------------|
|        | Payback RUB/RUB | Profitability, % | Payback RUB/RUB | Profitability, % |
| I      | Volgodonets | - 0.1321 | - 13.21 | - 0.6270 | - 6.27 |
|        | Pandero F₁ | 1.7472 | 74.72 | 1.3059 | 30.59 |
|        | Benefit F₁ | 1.8794 | 87.94 | 1.6413 | 64.13 |
| II     | Volgodonets | - 0.2322 | - 23.22 | - 0.1013 | - 10.13 |
|        | Pandero F₁ | 1.5936 | 59.36 | 1.2913 | 29.13 |
|        | Benefit F₁ | 1.7363 | 73.63 | 1.5740 | 57.40 |
| III    | Volgodonets | - 0.3115 | - 31.15 | - 0.1109 | - 11.09 |
|        | Pandero F₁ | 1.3975 | 39.75 | 1.2865 | 28.65 |
|        | Benefit F₁ | 1.4433 | 44.33 | 1.5285 | 52.85 |

4. Conclusion

Analyzing the materials presented in this work and based on the tasks set out in the formulation of a multifactorial experiment in the conditions of light chestnut soils of the Caspian lowland and chestnut soils of the Ergeninskaya Upland, the following conclusions can be drawn: 1 - basic farms in which the experiments were laid are the example of a high capital supply and power-to-weight ratio, both as a unit of area and an average worker; 2 - the experiment to identify the optimal rate of water supply and the dose of mineral nutrition showed that in both cases, both in the Chernoyarsk and in the Gorodishchensky districts, the optimal water supply option is 80% minimum water capacity, but in one case, namely in the Chernoyarsk district, the dose of mineral power supplies are N₅₆₅ active material, P₂₀₆ active material, K₂₀₆ active material, and in Gorodishchensky one - N₂₆₅ active material, P₇₅₀ active material, K₂₅₅ active material; 3 - the specified norms of water and mineral nutrition provided the highest yield in option I, both in Chernoyarsk and Gorodishchensky districts, while the Benefit F₁ hybrid in the first case exceeded the yield of 150 t/ha, in the second - 129 t/ha; 4 - the highest cost of output products is provided in option I for the Benefit F₁ hybrid, in particular, in the Chernoyarsk district more than 998.1 thousand RUB/ha, and in Gorodishchensky one - 795.6 thousand RUB/ha; 5 - the analysis of financial results and production efficiency showed that the cultivation of the Volgodonets variety in all the variants in both territories is unprofitable, and the hybrids are profitable, but the Benefit F₁ hybrid showed the highest effect, providing a profitability of 87.94% in the Chernoyarsk district and 64.13% - in Gorodishchensky one.
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