Economic efficiency of growing amaranth in Dagestan

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Abstract. Leaves and seeds of food types of amaranth are rich in water-soluble protein that does not contain gluten, and a variety of essential and minor components necessary for the functioning of the human body. The results of studying the technological methods of amaranth cultivation, its physiological and biochemical properties and economic efficiency in the Republic of Dagestan are presented. The introduction of highly productive agricultural crop amaranth with a high protein content with a full set of essential amino acids, biologically active substances and mineral elements opens up wide prospects for its multi-purpose use in agriculture, aimed at accelerating the scientific and technical development of agro-industrial production. Crop has great prospects both in Dagestan and in other regions of Russia, being a valuable raw material for creating functional products.

1. Introduction

In the modern world, introduction is widely used to replenish the assortment of agricultural crops with valuable food and feed properties. We are actively searching for plants that are sources of high-grade protein, pectin, biologically active substances and antioxidants. At the same time, agricultural crops that combine food and medicinal properties that effectively affect the physiological functions of a living organism are of particular value [1].

The problem of introduction of new food plants with an increased content of essential and biologically active substances is particularly relevant due to the lack of essential micronutrients in modern food products that are not synthesized in the human body. The lack of intake of biologically active substances, vitamins, minerals and antioxidants leads to a metabolic shift in metabolism and increases the risk of free radical pathologies (cardiovascular, cancer, food, etc.) [2,3].

The introduction of agricultural plants with high protein content, micronutrients, antioxidants and high productivity potential will solve an important state problem in providing the population of Russia with the necessary quantity and quality of safe food [4,5].

Introduction is the first stage in the transfer of plants to a new habitat, followed by the selection of the most productive and stable forms in local agro-climatic conditions in order to create modern varieties suitable for both industrial crops and for growing on households and farms, as well as the development of technology for their cultivation, reproduction, storage and processing. Large areas in the South of the country are characterized by a lack of moisture, non-irrigated fields account for up to 70% of the total area, saline and acidic soils are often found. Therefore, for highly productive
industrial management of crop production and animal husbandry, it is necessary to introduce multifunctional plants with such qualities as resistance to biotic and abiotic stresses, high productivity and nutritional value of products, and suitability for mechanized technologies of growing in the open ground [6]. These plants include the pseudo grain agricultural crop amaranth (Amaranthus) of food, feed, decorative, medicinal and technical use [7].

Amaranth is a high-protein crop with increased nutritional and pharmacological value, characterized by drought resistance, tolerance to saline, alkaline and acidic soils, increased productivity of seeds and leaf biomass with a high content of biologically active substances with antioxidant activity. Due to the shortage of domestic sources of feed protein, this problem can be partially solved by amaranth leaves, which contain a significant amount of protein and antioxidants. Leaves and stems of young plants are nutritious and health food for birds, rabbits, pigs and cattle.

The aim of the research is to conduct an economic assessment of the use of introduced varieties of amaranth breeding of FSBNI FSCVG in the agricultural production of the Dagestan Republic.

2. Materials and methods
The objects of research were varieties of amaranth selection of the FSBNI FSCVG (previously VNIISSOK) Krepysh, Valentina and Don Pedro.

The soil of the experimental site in the village of Ashagastal of Suleiman-Stalsky district is well cultivated and has a high level of natural fertility. Salt pH 7.5-7.7, humus content in the arable layer ranges from 2.8 to 4.4 %, nitrogen from 5.6 mg/100 g to 14 mg/100 g, phosphorus content in the soil – 6.8-8.0 mg/100 g, potassium content – 40.0-43.2 mg/100g. The amount of absorbed bases – 18.1-27.9 mg-EQ/100 g.

3. Results
The results of the analysis show that both the type and chemical composition of the soil of the studied area of southern Dagestan are favorable for the cultivation of amaranth plants.

Weather conditions during the growing season were analyzed based on data provided by the Kasumkent Meteorological station. The average annual air temperature for all the years of research was higher than the long-term average by 2°C (in 2015 and 2016) and 3°C (in 2017 and 2018) (table 1).

Positive period (above +5°C) of the average daily air temperature in the region lasts from April to October, which provides enough time for the growth, development and full maturation of seeds, even such a late-maturing variety of amaranth as Don Pedro.

In order to determine the optimal period for sowing seeds in southern Dagestan, 2 terms were studied – in the second decade of April (with a stable transition of average daily air temperatures through +10°C) and in the first decade of May (with a stable transition of average daily air temperatures through +15°C) (table 2). Soil preparation was carried out according to the standard technology adopted for vegetable crops. Seeding was carried out to a depth of 1.5 to 2 cm. After germination and thinning, the distance between individual plants in a row was from 30 to 40 cm [8].

The analysis of the results showed that the second period of seed sowing is more favorable for the cultivation of amaranth in southern Dagestan, which may be due to the temperature regime of the territory – higher air temperatures (the average daily air temperature in July-August for the years of research was in the range of 24-27.5°C). In addition, it was noted that if in April the daily temperature difference of the air fluctuates within 14-20°C, then by June the temperature difference significantly decreased.

Table 1. Mean annual characteristics of the water-temperature regime in v. Ashagastal Suleyman-Stalsky district.

| Months of the year | Absolute maximum, °C | Absolute minimum, °C | Long-term average value, °C | Amount of precipitation, mm |
|-------------------|----------------------|----------------------|-----------------------------|-----------------------------|
| January           | 20.2                 | -21.0                | 0.0                         | 19                          |
Table 2. The timing of the onset of phenophase of amaranth varieties depending on the time of sowing seeds, the village of Ashagastal Suleiman-Stalsky district (2015-2017).

| Variety   | Year of research | The timing of the onset of phenophase after sowing seed, day | Seed maturation and harvesting |
|-----------|------------------|-------------------------------------------------------------|-------------------------------|
|           |                  | Emergence of sprouts | Budding | Flowering |                                    |
|           |                  |                    |         |           |                                    |
|           | Seeding 1 term (average daily air temperature > + 10°C) |                    |         |           |                                    |
| Krepysh   | 2015             | 8                  | 54      | 64        | 129                                    |
|           | 2016             | 7                  | 52      | 63        | 125                                    |
|           | 2017             | 7                  | 51      | 58        | 123                                    |
| Valentina | 2015             | 6                  | 55      | 63        | 126                                    |
|           | 2016             | 6                  | 51      | 60        | 123                                    |
|           | 2017             | 7                  | 48      | 54        | 120                                    |
| Don Pedro | 2015             | 12                 | 58      | 83        | 150                                    |
|           | 2016             | 13                 | 55      | 81        | 158                                    |
|           | 2017             | 11                 | 52      | 78        | 146                                    |
|           | Seeding 2 term (average daily air temperature > + 15°C) |                    |         |           |                                    |
| Krepysh   | 2015             | 6                  | 19      | 48        | 110                                    |
|           | 2016             | 5                  | 17      | 45        | 108                                    |
|           | 2017             | 5                  | 17      | 43        | 108                                    |
| Valentina | 2015             | 6                  | 18      | 47        | 112                                    |
|           | 2016             | 4                  | 17      | 44        | 108                                    |
|           | 2017             | 4                  | 16      | 42        | 107                                    |
| Don Pedro | 2015             | 8                  | 48      | 72        | 129                                    |
|           | 2016             | 7                  | 43      | 68        | 120                                    |
|           | 2017             | 7                  | 42      | 65        | 118                                    |

The growing season of early-maturing varieties Valentina and Krepysh from the moment of seeding to full maturation lasts 3-3.5 months. The length of the inflorescence reaches, on average, for the Krepysh variety – 68 cm, for the Valentine variety - 72 cm; the height of the plants – 220-240 cm, respectively.

The period of development of late-maturing varieties Don Pedro was a little longer and lasted on average 4 months – i.e. captured both the first and second decade of September, however, for the climatic conditions the southern Dagestan is characterized by warm September (mean daily
temperature ranges from 20-22°C) therefore, this variety reaches full maturity seeds. The height of plants of the Don Pedro variety is on average 250-260 cm; the length of the inflorescence is 75 cm.

In 2015-2018, the study of the biochemical composition of seeds of varieties of amaranth Valentina, Krepysh and Don Pedro grown in the foothills of southern Dagestan was conducted [9].

Analysis of the results showed that the seeds of amaranth varieties Valentina, Krepysh and Don Pedro differ in a rich content of protein, a valuable component consumed by humans and used as food for farm animals and birds. At the same time, the highest protein content is distinguished by seeds of the Valentina variety, the quantitative content of which reaches almost 20%. Then there are varieties of amaranth Don Pedro, and then Krepysh (table 3).

The highest fat content is found in the seeds of the Krepysh variety, about 8.9%. In the varieties of Valentina and Don Pedro, it is close to 5%. The carbohydrate content, depending on the year and variety, ranges from about 62% to 67%, i.e. it is about 2/3 of the total weight of seeds. At the same time, among carbohydrates, the most starch is about 40% to 53% by year.

To determine the feed value of introduced amaranth varieties, in 2017-2018 we conducted a comparative study of the main feed characteristics of varieties Valentina, Krepysh and Don Pedro grown in southern Dagestan: nutritional value, energy value (calorific value), total vitamin and antioxidant value, yield, the level of feed units per 1 ton of product [8,9].

| Table 3. Biochemical composition of seeds of introduced varieties of amaranth. Harvest 2017 and 2018 Southern Dagestan. |
|-------------------------------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| Quantitative content of the substance, %        | 2017 variety    | 2018 variety    |                  |                  |                  |                  |
| Protein                                        | Valentina       | Krepysh         | Don Pedro        | Valentina       | Krepysh         | Don Pedro        |
|                                                | 19.14           | 14.62           | 17.59            | 19.15           | 16.24           | 16.90            |
| Fats                                           | 3.88            | 8.44            | 4.81             | 4.82            | -               | 4.49             |
| Carbohydrates, total content                   | 61.72           | 61.70           | 62.11            | 66.85           | -               | 64.40            |
| Starch                                         | 43.19           | 52.72           | 39.39            | 39.67           | -               | 37.96            |
| Cellulose                                      | 2.27            | 5.68            | 6.63             | 2.39            | -               | 5.66             |
| Glucose                                        | -               | -               | -                | 1.36            | 1.19            | 1.40             |
| Other sugars                                   | -               | -               | -                | 0.23            | 0.25            | 0.19             |
| Water (humidity)                               | 10.68           | 12.68           | 11.40            | 11.46           | -               | 10.18            |

As a control, the corn variety VIR-156, traditionally used in Dagestan as a feed component, was taken.

The highest feed indicators are in the varieties Valentina and Don Pedro, at the same time, the variety Krepysh has the highest calorific values, because the content of starch, fat and carbohydrates exceeds the other varieties of amaranth.

It should be noted that the varieties of amaranth in all studied indicators significantly exceed the traditional feed grade of corn. Thus, the average yield of amaranth varieties is 2.6 times higher than that of VIR-156 corn.

No less significant differences were noted for other studied indicators – the excess is 1.2 – 2.7 times (depending on the indicator).

A great advantage of amaranth over other forage crops is its high biological productivity. The yield of green mass exceeds the productivity of the traditional silage crop-corn and is on average 33.3 t/ha. In the vegetative mass of amaranth, the protein content is by 1.8 times, and the lysine content is by 3 times more than in corn. In terms of amino acid balance, amaranth leaf protein is one of the best for animals.

The economic efficiency of amaranth cultivation for feed purposes is calculated based on the technological map at market prices [10]. To calculate the yield in feed units the coefficient of content of feed units in 100 kg of green mass products was used: corn - 16, amaranth - 17 (table 4).
Table 4. Economic efficiency of amaranth cultivation for forage purposes in comparison with traditional forage culture of Dagestan (calculation per 1 ha).

| Crop       | Yield (green mass), t | Feed units/t | The cost of production, thousand rubles | The cost of gross production, thousand rubles | Cost, 1 c, rubles | Net profit, thousand rubles | Profitability level, % |
|------------|-----------------------|--------------|----------------------------------------|---------------------------------------------|------------------|----------------------------|------------------------|
| Corn       | 12.7                  | 2.03         | 7.41                                   | 20.3                                        | 58.35            | 12.9                       | 174                    |
| Amaranth   | 33.3                  | 5.66         | 9.50                                   | 56.6                                        | 28.53            | 47.1                       | 496                    |

4. Summary
According to the results of the research, it is shown that economically, the amaranth crop for green feed exceeds corn in yield by 2.62 times, in yield of feed units by 2.72 times, in net income by 3.65 times and profitability by 2.85 times. Thus, the cultivation of the studied introduced varieties for green fodder in the conditions of southern Dagestan is more cost-effective in comparison with the traditional feed crop of corn.

5. References

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