Study of New Technologies for Cultivation of Solanaceous Vegetable Crops in Short Vegetation Period Regions of Armenia

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Abstract. The article considers the impact of new integrated technologies (mulching, drip irrigation, use of wooden sticks for each plant, use of new biofertilizers) in the cultivation of solanaceous vegetable crops (tomato, pepper, eggplant) in regions with a short growing season. The study of new technologies in the cultivation of solanaceae crops in regions of short vegetation period shows the effectiveness of the impact of these technologies on the biological characteristics, economic- valuable and qualitative indicators. New technologies contributed to early maturity, increased yield and quality of fruits, resistance to diseases and pests. New technologies can be effectively implemented in the republic and similar regions of the globe.

1. Introduction
Solanaceous crops occupy a large place among vegetables. Tomato fruits have high nutritional, taste and dietary properties. They contain: sugars, including fructose and glucose, pectins, hemicellulose, fibre, organic acids, including citric acid, malic acid, oxalic acid, tartaric acid, essential and substitutable amino acids, beta-carotene, vitamins E, C, B1, B2, B6, B9, PP, lycopene, biotin, pantothenic acid, macro- and microelements etc. The fruits also contain 3–5 mg% tomatin, which determines their phytocidal properties. The technology of fruit processing makes it possible to preserve from 80% to 100% of biologically valuable substances in tomato products [1, 2, 3, 4, 5].

No less rich in vitamins and other biologically active substances are peppers. They contain as much vitamin C as lemon fruit. Pepper fruits are also rich in carotene, thiamine, nicotinic and folic acids, proteins and mineral salts. At the stage of biological ripeness they contain three types of basic sugars: glucose, fructose, sucrose. In this regard, peppers can be included in the category of dietary products [6, 7, 8, 9].

Eggplant fruits seeds contain outstanding antioxidants-steroidal glycosides, large amounts of B group vitamins, PP1 ash elements of potassium, calcium, phosphorus, sulfur, iron, magnesium [10, 11, 12, 13, 14].

For Armenia, climatic conditions of open ground of highland regions (Gegharkunik marz, Sevan basin) are unfavorable for cultivation of solanaceous vegetable crops. The main limiting factors are the short growing season.

The Sevan basin region is mainly involved in the cultivation of potato, grain and legume crops. Solanaceous vegetable crops are cultivated only in households.
In Armenia, cultivation of solanaceous vegetable crops is mainly practiced in the Ararat Plain. Transportation of these crops to the foothills and mountainous regions is expensive, which naturally affects the price of products. Due to the urgency of the issue we had the task to study and introduce new promising cultivation technologies and early maturing varieties of solanaceous vegetable crops with high productivity, marketability and quality of fruits, resistance to diseases and pests when grown in regions with a short growing season.

2. Material and methods
Studies on new technologies of cultivation of solanaceous vegetable crops were conducted in Atsarait village of Ghawar district of Gegharkunik region during 2014–2017.

Experiments on the study of new cultivation technologies of nightshade vegetable crops were conducted in four replications according to the methodology of the World Vegetable Center (AVRDC) [15]. Feeding area (90–70)x25cm for tomatoes, (90–70)x30cm for eggplants, (90–70)x20cm for peppers. The standard was the traditional cultivation technology of solanaceous vegetable crops. The method of analysis of variance was used [16]. Variety characterization is described according to the methodology of VNIIR, AVRDC and IPGRI (Bioversity International) [17, 18, 19, 20, 21]. The biochemical composition of the fruit was determined: dry matter – by refractometer, sugars - according to Bertrand, vitamin “C” by Murry, acidity – by titration method [22].

Below are the pictures of the Armenian varieties under study – Anait 351 (figure 1), Renaissance (figure 2), Rubina (figure 3), Natali (figure 4), Armenian Krasivy (figure 5), Gita (figure 6), F1Carine (figure 7), Varderens (figure 8).
The following is a brief description of the technologies under study.

Traditional cultivation technology (control) (figure 9). The 40-day-old seedlings are planted on the soil of the open field. They are watered in the usual way, in beds. Mineral fertilizer is applied, usually nitrate, 2 times, 1 after planting in 20 days, 2 after planting in 40 days. In our experiments we used nitrate at the rate of 250 kg per 1 ha. The plants have been weeded three times. The plot was after 8–10 days. To prevent disease and control pest, the pesticides Ridomil Gold and Karate were used 2 times at 10-day intervals.
Figure 9. Traditional cultivation technology. New cultivation technology (figure 10).

Before planting seedlings in the open ground, the beds are mulched with polyethylene film. Under the film, the pipes of drip irrigation are installed. 40 day-old seedlings are planted in a mulched field. The plants are watered by drip irrigation, every other day. Liquid biofertilizer with drip irrigation is applied (20 days after planting). Additional fertilizing is applied 3 times at 10-day intervals. In our experiments, we used the Armenian new biofertilizer Ecobifid+, at a rate of 10 liters per 1 hectare. After planting, when the plants reached 20–25 cm, a one-metre wooden stick was attached to each plant. During the growing season the plants were shaped and attached to the sticks. We've been doing some pinching on the tomatoes. We took care of the plants 3 times. As preventive measures, we have been controlling diseases and pests using the pesticides Ridomil Gold and Karate 2 times with 10 day intervals.

Figure 10. New cultivation technology.

3. Results and discussion
The results of phenological observations showed that in the studied tomato varieties Anait 351, Renaissance, Rubina the period from sprouting to fruit ripening was 112; 111; 100 days /traditional technology/ and 90; 87; 87 days /new technology/. In Natali peppers, the period from sprouting to fruit ripening was 108 and 95 days, respectively, in hot peppers Armenian beautiful and Gita 97; 105 days 85; 97 days /new technology/, in eggplant hybrid F1 Karine -116, in Varderes – 120 days /traditional technology/, respectively, 103 and 107 days /new technology/. When cultivated using the new technology, all varieties and hybrids exceeded the control /traditional technology/, respectively 22; 24;
23; 13; 12; 7; 13;13 days. The average weight of mature fruit of the studied varieties and hybrids Anait 351, Renaissance, Rubina, Natali, Armenian beautiful, Gita, and hybrid F1 Karine and in variety Varderes was 96.3 respectively; 71.9; 96.8; 80.6; 28.7; 5.4; 190.3; 170.9 grams /traditional technology/, 130.5; 80.2; 15.4; 90,8; 35.1; 7.2; 250.4; 220.8 grams /new technology/. The average yield of the studied varieties and hybrids Anait 351, Renaissance, Rubina, Natalie, Armenian beautiful, Gita and hybrid F1 Karine, the Varderes variety was 308, respectively; 316.8; 96.8; 264; 101.2; 44; 127.6; 88 c/ha /traditional technology/, 880; 792; 198; 396; 220; 74.8; 440; 396 c/ha /new technology/. The best results were shown by the varieties and hybrids when cultivated by new technology. The yield increase was 580, respectively; 475.2; 101.2; 132; 118.8; 30.8; 312.4; 308 c/ha and 65.9; 60; 51,1; 33.3; 54; 41,1; 71; 77 % (table. 1).

| Variety          | Hybrid | Variations | Period from sprouting to first harvest, days | Average weight of mature fruit, g. | Yield, c/ha | Yield increase, c/ha | Yield increase, % |
|------------------|--------|------------|---------------------------------------------|-----------------------------------|-------------|----------------------|-------------------|
| Anait 351        |        | *1         | 112                                         | 96.3                              | 308.0       | -                    | -                 |
|                  |        | **2        | 90                                          | 130.5                             | 880.0       | 580.0                | 65.9              |
| Renaissance      |        | *1         | 111                                         | 71.9                              | 316.8       | -                    | -                 |
|                  |        | **2        | 87                                          | 80.2                              | 792.0       | 475.2                | 60.0              |
| Rubina           |        | *1         | 100                                         | 12.3                              | 96.8        | -                    | -                 |
|                  |        | **2        | 87                                          | 15.4                              | 198.0       | 101.2                | 51.1              |
| Sweet pepper     |        |            |                                             |                                    |             |                      |                   |
| Natali           |        | *1         | 108                                         | 80.6                              | 264.0       | -                    | -                 |
|                  |        | **2        | 95                                          | 90.8                              | 396.0       | 132.0                | 33.3              |
| Armenian beautiful |    | *1         | 97                                          | 28.7                              | 101.2       | -                    | -                 |
|                  |        | **2        | 85                                          | 35.1                              | 220.0       | 118.8                | 54.0              |
| Gita             |        | *1         | 105                                         | 5.4                               | 44.0        | -                    | -                 |
|                  |        | **2        | 97                                          | 7.2                               | 74.8        | 30.8                 | 41.1              |
| Eggplant         |        |            |                                             |                                    |             |                      |                   |
| F1 Karine        |        | *1         | 116                                         | 190.3                             | 127.6       | -                    | -                 |
|                  |        | **2        | 103                                         | 250.4                             | 440.0       | 312.4                | 71.0              |
| Varderes         |        | *1         | 120                                         | 170.9                             | 88.0        | -                    | -                 |
|                  |        | **2        | 107                                         | 220.8                             | 396.0       | 308.0                | 77.0              |

*1-Traditional technology (Control), **2-New technology
LSD 0.05 = 15.2 kg/ha, Sx% = 2.2 Tomato
LSD 0.05 = 17.4 kg/ha, Sx% = 2.4 Sweet pepper
LSD 0.05 = 18.3 kg/ha, Sx% = 3.1 Hot peppers
LSD 0.05 = 16.8 kg/ha, Sx% = 2.5 Eggplant

The results of the research on morphological characteristics of solanaceous vegetable crops showed that the shape and colouring of fruits of varieties and hybrids in the studied technologies did not change.[Table 2] The results of the research showed that the length of the fruit in the studied varieties and hybrids Anait 351, Renaissance, Rubina, Natali, Armenian beautiful, Gita and hybrid F1 Karine was 3.5, respectively in varieties Varderes; 5.3; 1.6; 9.1; 12.2; 5.5; 21.4; 7.6 cm /traditional technology/, 6.2; 9.2; 2.1; 11.4; 16.7; 7.5; 32.6; 10.5 cm /new technology/, and the width of the fruit, respectively, 3.6;
1.5; 1.7; 2.5; 1.7; 0.5 cm /traditional technology/, 4.1; 2.1; 1.9; 3.5; 2.2; 0.9; 3.5; 8.6 cm /new technology/ (table 2).

**Table 2.** Morphological characteristics of studied nightshade vegetable varieties.

| Variety Hybrid | Variations | Fruit shape | Fruit length, cm | Fruit width, cm | Fruit coloring in Technical ripeness | Biological ripeness |
|----------------|------------|-------------|-----------------|-----------------|--------------------------------------|---------------------|
| Tomato         |            |             |                 |                 |                                      |                     |
| Anait 351      | *1         | round       | 3.5             | 3.6             | white green                         | red                 |
|                | **2        | round       | 6.2             | 4.1             | white green                         | red                 |
| Renaissance    | *1         | oval        | 5.3             | 1.5             | green                               | red                 |
|                | **2        | oval        | 9.2             | 2.1             | green                               | red                 |
| Rubina         | *1         | round       | 1.6             | 1.7             | green                               | red                 |
|                | **2        | round       | 2.1             | 1.9             | green                               | red                 |
| Sweet pepper   | *1         | prismatic   | 9.1             | 2.5             | green                               | orange              |
|                | **2        |             | 11.4            | 3.5             |                                      |                     |
| Hot pepper     | *1         | long        | 12.2            | 1.7             | yellow                              | red                 |
| Armenian beautiful | **2       | long        | 16.7            | 2.2             | yellow                              | red                 |
| Gita           | *1         | short       | 5.5             | 0.5             | green                               | red                 |
|                | **2        | short       | 7.5             | 0.9             | green                               | red                 |
| Eggplant       | *1         | sickle-shaped | 21.4            | 3.6             | black                               | -                   |
|                | **2        | sickle-shaped | 32.6            | 3.5             | black                               | -                   |
| F1Karine       | *1         | round       | 7.6             | 5.5             | dark purple                         | -                   |
|                | **2        | round       | 10.5            | 8.6             | dark purple                         | -                   |

*1-Traditional technology (Control), **2-New technology

The results of research on qualitative traits of solanaceous vegetable crops showed that dry matter in the studied varieties and hybrids Anait 351, Renaissance, Rubina, Natali, Armenian beautiful, Gita and hybrid F1Karine, in the variety Varderes was 6.2, respectively; 7.1; 7; 5.6; 4.6; 4.6; 9.7; 10.5% /traditional technology/, 6.9; 7.3; 7.2; 6.8; 4.8; 4.7; 10.9; 11.7% /new technology/, sugar, respectively, 3.3; 3.4; 3.4; 2.4; 1.5; 1.3; 2.9; 3.2 /traditional technology/, 3.5; 3.5; 3.6; 3.5; 1.6; 1.4; 3.1;3.4% /new technology, vitamin C, respectively, 25.22; 37.20; 35,60; 120.85; 80.55; 79.85; 6.85; 6.95 mg% /traditional technology/, 27.85; 40.75; 39.45; 150.60; 95.70; 90.45; 7.80; 7.90 mg% /new technology/, acidity, respectively, 0.51; 0.50; 0.52; 0.45; 0.45; 0.45; 0.42% / conventional technology/, 0.45; 0.46; 0.48; 0.42; 0.43; 0.42; 0.45; 0.41% /new technology/. The best results were shown by the varieties and hybrids when cultivated by new technology (table 3).
Table 3. Qualitative indicators of studied varieties of nightshade vegetable crops (average for 3 years).

| Variety Hybrid | Variations | Content in fruits |
|----------------|------------|-------------------|
|                |            | Dry matter, %     |
|                |            | Sugar, %          |
|                |            | Vitamin C, mg%    |
|                |            | Acidity, %        |
| Tomato         |            |                   |
| Anait 351      | *1         | 6,2               |
|                |            | 3,3               |
|                |            | 25,22             |
|                |            | 0,51              |
|                | **2        | 6,9               |
|                |            | 3,5               |
|                |            | 27,85             |
|                |            | 0,45              |
| Renaissance    | *1         | 7,1               |
|                |            | 3,4               |
|                |            | 37,20             |
|                |            | 0,50              |
|                | **2        | 7,3               |
|                |            | 3,5               |
|                |            | 40,75             |
|                |            | 0,46              |
| Rubina         | *1         | 7,0               |
|                |            | 3,4               |
|                |            | 35,60             |
|                |            | 0,52              |
|                | **2        | 7,2               |
|                |            | 3,6               |
|                |            | 39,45             |
|                |            | 0,48              |
| Sweet pepper   |            |                   |
| Natali         | *1         | 5,6               |
|                |            | 2,4               |
|                |            | 120,85            |
|                |            | 0,45              |
|                | **2        | 6,8               |
|                |            | 3,5               |
|                |            | 150,60            |
|                |            | 0,42              |
| Hot pepper     |            |                   |
| Armenian beautiful | *1 | 4,5             |
|                |            | 1,5               |
|                |            | 80,55             |
|                |            | 0,45              |
|                | **2        | 4,8               |
|                |            | 1,6               |
|                |            | 95,70             |
|                |            | 0,43              |
| Gita           | *1         | 4,6               |
|                |            | 1,3               |
|                |            | 79,85             |
|                |            | 0,45              |
|                | **2        | 4,7               |
|                |            | 1,4               |
|                |            | 90,45             |
|                |            | 0,42              |
| Eggplant       |            |                   |
| F1 Karine      | *1         | 9,7               |
|                |            | 2,9               |
|                |            | 6,85              |
|                |            | 0,45              |
|                | **2        | 10,9              |
|                |            | 3,1               |
|                |            | 7,80              |
|                |            | 0,45              |
| Varderes       | *1         | 10,5              |
|                |            | 3,2               |
|                |            | 6,95              |
|                |            | 0,42              |
|                | **2        | 11,7              |
|                |            | 3,4               |
|                |            | 7,90              |
|                |            | 0,41              |

*1-Traditional technology (Control)  
**2-New technology

4. Conclusion
The study of new technologies in the cultivation of solanaceae crops in regions of short vegetation period shows the effectiveness of the impact of these technologies on the biological characteristics, economically valuable and qualitative indicators. The new technology contributed to early maturity, increased yield and quality of fruits, resistance to diseases and pests. The new technology can be effectively implemented in the republic and similar regions of the globe.

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