INTERNATIONAL JOURNAL FOR INNOVATIVE RESEARCH IN MULTIDISCIPLINARY FIELD
ISSN(O): 2455-0620 [Impact Factor: 9.47]
Monthly, Peer-Reviewed, Refereed, Indexed Journal with IC Value : 86.87
Volume - 10, Issue - 8, August - 2024

DOIs:10.2015/IJIRMF/202408016 --:-- Research Paper / Article / Review

Scientific basis of resource-efficient technologies in greenhouses of Uzbekistan

[1]A. Ubaydillaev, [2]M. Avliyakulov, [3]R. Muradov
[1]"Tashkent institute of irrigation and agricultural mechanization engineers" National Research University
[2]Cotton breeding, seed production and agrotechnologies research institute
[3]Swiss Agency for Development and Cooperation SADC
Email - [1]anubaydilllayev@gmail.com

Abstract: *The world attaches particular importance to the issue of ensuring a guaranteed supply of quality food to the population, rational and efficient use of available land, water, energy, food and drinking resources. Currently, developed countries "...have decided to ensure food security through the development of greenhouse farming." In this regard, special attention is paid to achieving high productivity in greenhouses, improving the design of greenhouses, rational use of water and energy resources, developing water and resource-saving irrigation technologies, and increasing efficiency of use based on the use of mathematical modeling methods. It consists in developing water and resource efficient technology of growing tomato plants.*

Key Words: *Greenhouse, water-saving technologies, greenhouse conditions, optimal irrigation, save energy resources, climate, nutrition, light conditions, seedling density.*

1. INTRODUCTION:

International conferences dedicated to the sustainable development of agriculture and scientific research, such as the use of water-saving technologies in greenhouse conditions, the effective use of available land and water resources through the management of optimal irrigation, climate, nutrition, and light conditions. It is of particular importance to carry out targeted scientific-research works in these areas[8, 30].

Water resources, consistent development of agricultural production, further strengthening of the country's food security, production of ecologically clean products, and development of greenhouse conditions for significantly increasing the export potential of the agricultural sector are considered to be the basis of the reforms implemented in our republic. In the Development Strategy of the Republic of Uzbekistan for 2020-2030 [7], Including the use of water-saving technologies, the development of irrigation procedures for agricultural crops in greenhouse conditions, the efficient use of existing water, land, food and energy resources, and the improvement of technologies that allow further development of greenhouse farms it is becoming important to carry out directed scientific research [17].

The steady increase in the population of our country has increased their interest in the field of irrigated agriculture. It creates an opportunity to make additional income through the development of agricultural lands and settlements. Even in the cold days of winter in rural areas, the cultivation of vegetable products is one of the urgent issues. It is desirable to produce plant products with low content of heavy metals, nitrates and other harmful substances and of good quality for consumption[19].

Production of environmentally friendly products using new technologies that save energy resources in greenhouse conditions remains an urgent task.

Reducing the negative impact of product production on protected soils, using artificial light sources, using energy-saving technologies, and improving the technologies of intensive cultivation of plants are considered desirable. It is possible to save resources by using technologies of greenhouse conditions [9].

Air temperature, soil salinity, location of seedlings, irrigation and light standards in protected areas for year-round cultivation of vegetable plants in greenhouse conditions, achieving potential productivity, economically profitable it is required to study the analysis and results of the scientific developments carried out in the field

In achieving this goal:

– Research of water and resource-efficient technology in the cultivation of tomato plant under the influence of local greenhouse indicators (light duration, greenhouse depth, seedling thickness, average temperature difference, soil salinity level);

– development of tomato plant watering procedure in local greenhouse conditions and determination of seasonal irrigation norm and productivity based on fractional factor experiments;

– thermal regime of the greenhouse, soil moisture dynamics, nutrients in the cultivation of tomato plants mathematical modeling of consumption and definition of acceptable criteria.

2. RESEARCH METHODS : In the course of the research, generally accepted methods of conducting experiments in greenhouse conditions, as well as observational data processing, analysis, comparison, mathematical statistics, mathematical modeling, numerically tested numerical methods were used.

3. ANALYSIS AND DISCUSSION:

Seedling placement scheme. One of the factors affecting the productivity of the tomato plant is the layout of seedlings. There are several methods of planting tomato plants, which are selected depending on the cultivation technology [16]. In our research (Fig. 1) we used 40x90x70, 50x80x80, 40x120x120 35x120x120 planting schemes. In this case , the yield obtained from the number of seedlings corresponding to 1 m^2 area was studied.

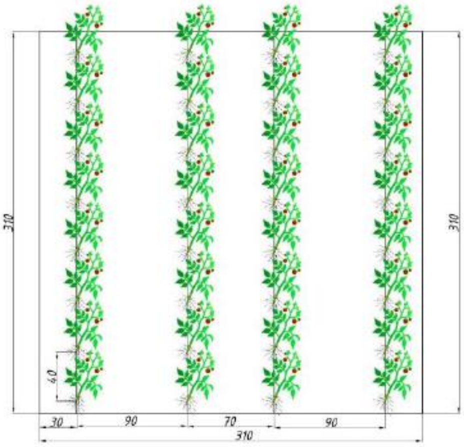


Figure 1. Planting method 40x90x70

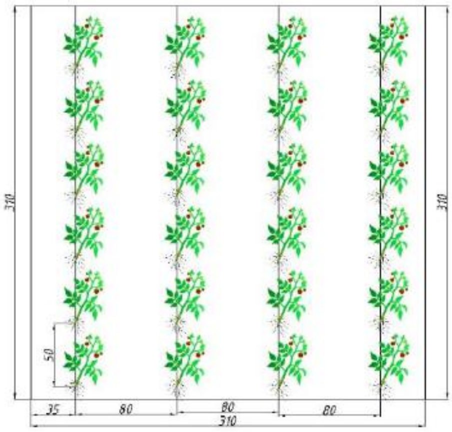


Figure 2. 50x80x80 planting method

Figure 1. In the 40x90x70 planting method 3,2 tomato seedlings are suitable for 1 m^2 area. Here, the distance between seedlings is 40 cm, and the distance between rows is 90 and 70 cm.

Figure 2. In the 50x80x80 planting method, 2,5 tomato plants are placed on 1 m^2 In this planting method, the distance between seedlings is 50 cm. The distance between the rows is 80 cm.

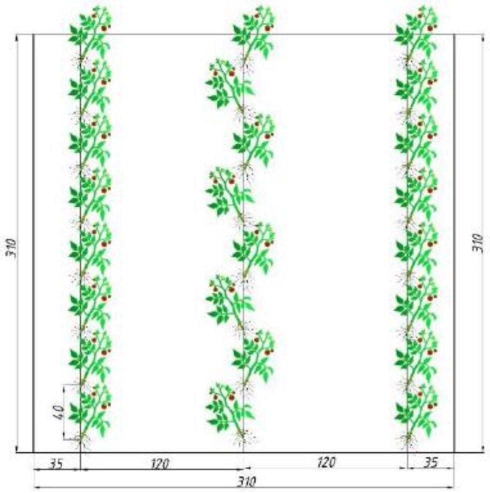


Figure 3. Planting method 40x120x120

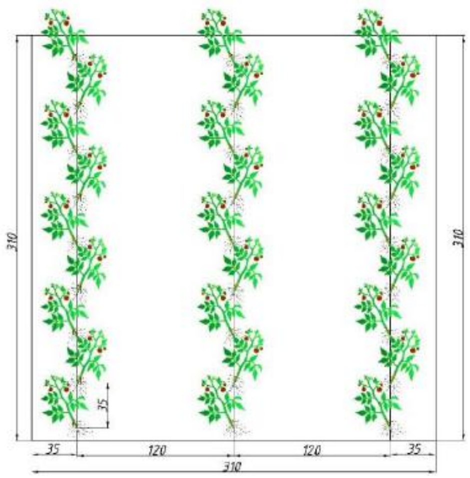


Figure 4. 35 x 120 x 120 planting method

Figure 3. In the 40x120x120 planting method, 2,5 tomato plants are placed on 1 m^2 In this planting method, the distance between seedlings is 40 cm. The distance between the rows is 120 cm.

INTERNATIONAL JOURNAL FOR INNOVATIVE RESEARCH IN MULTIDISCIPLINARY FIELD
ISSN(O): 2455-0620 [Impact Factor: 9.47]
Monthly, Peer-Reviewed, Refereed, Indexed Journal with IC Value : 86.87
Volume - 10, Issue - 8, August - 2024

Figure 4. In the 35x120x120 planting method, 2,7 tomato plants are placed on 1 m^2 In this planting method, the distance between seedlings is 35 cm. The distance between the rows is 120 cm. When the tomato plant is pulled to the upper wire, it is necessary to pull the plant up from both sides as the distance between the seedlings narrows.

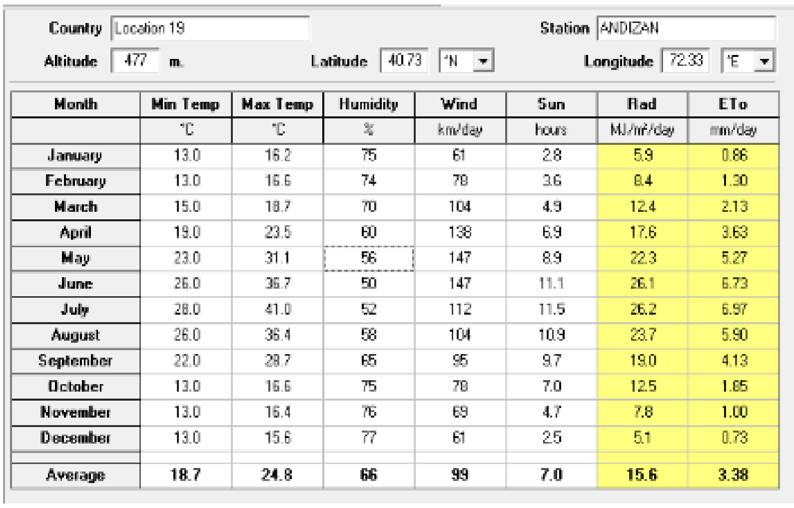
	
Figure 5. Sampling of soil in excavated conditions	**Figure 6. Soil sampling**

Temperature measurement. Greenhouse conditions were measured using a thermometer inside and outside the greenhouse at 8:00 am and 2:00 pm, with a stationary thermometer placed 2 m above the ground to monitor temperature throughout the growing season [14]. The average daily temperature was obtained by summing up the results of each temperature. The daily average temperatures were combined to determine the monthly average temperature. Electronic (Fig. 7) and mercury (Fig. 8) temperature measuring devices were used. Temperature outside the greenhouse ClimWAT [3]

Figure 7. Electronic thermometer

Figure 8. Mercury thermometer

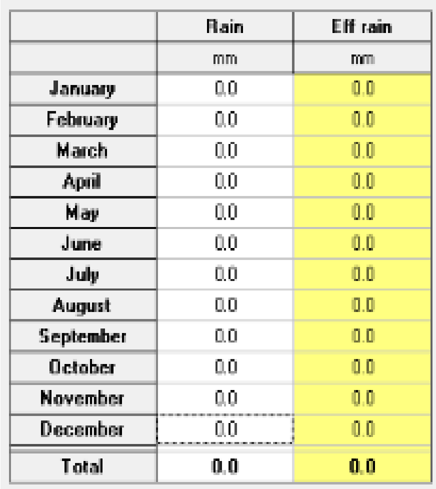
Taking into account that the amount of standard evapotranspiration in the CropWat program is calculated according to the Penmann-Monteit formula, an A-type evaporator design was used to determine the suitability of this formula for greenhouse conditions. Experiments conducted in the conditions of local greenhouses of different constructions showed the high accuracy of the Penmann-Monteit formula [10].



Country: Location 19 | Station: ANDIZAN
Altitude: 477 m. | Latitude: 40.73 °N | Longitude: 72.33 °E

Month	Min Temp	Max Temp	Humidity	Wind	Sun	Rad	ETo
	°C	°C	%	km/day	hours	MJ/m²/day	mm/day
January	13.0	16.2	75	61	2.8	5.9	0.86
February	13.0	16.6	74	78	3.6	8.4	1.30
March	15.0	18.7	70	104	4.9	12.4	2.13
April	19.0	23.5	60	138	6.9	17.6	3.63
May	23.0	31.1	56	147	8.9	22.3	5.27
June	26.0	36.7	50	147	11.1	26.1	6.73
July	28.0	41.0	52	112	11.5	26.2	6.97
August	26.0	36.4	58	104	10.9	23.7	5.90
September	22.0	28.7	65	95	9.7	19.0	4.13
October	13.0	16.6	75	78	7.0	12.5	1.85
November	13.0	16.4	76	69	4.7	7.8	1.00
December	13.0	15.6	77	61	2.5	5.1	0.73
Average	18.7	24.8	66	99	7.0	15.6	3.38

Figure 9. Climate Indicator (CropWAT)



	Rain	Eff rain
	mm	mm
January	0.0	0.0
February	0.0	0.0
March	0.0	0.0
April	0.0	0.0
May	0.0	0.0
June	0.0	0.0
July	0.0	0.0
August	0.0	0.0
September	0.0	0.0
October	0.0	0.0
November	0.0	0.0
December	0.0	0.0
Total	0.0	0.0

Figure 10. rainfall (CropWAT)

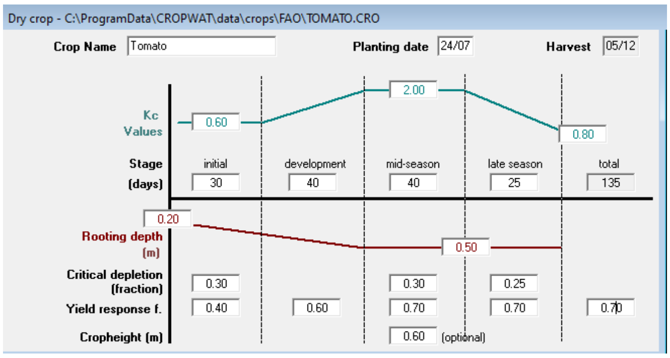


Figure 11. Development (CropWAT)

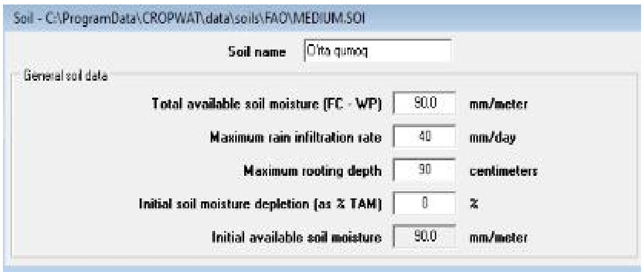
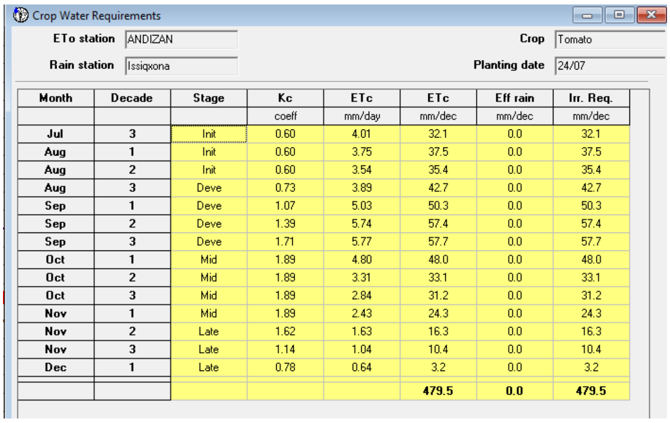


Figure 12. Soil texture (CropWAT)



ETo station: ANDIZAN | Crop: Tomato
Rain station: Issiqxona | Planting date: 24/07

Month	Decade	Stage	Kc	ETc	ETc	Eff rain	Irr. Req.
			coeff	mm/day	mm/dec	mm/dec	mm/dec
Jul	3	Init	0.60	4.01	32.1	0.0	32.1
Aug	1	Init	0.60	3.75	37.5	0.0	37.5
Aug	2	Init	0.60	3.54	35.4	0.0	35.4
Aug	3	Deve	0.73	3.89	42.7	0.0	42.7
Sep	1	Deve	1.07	5.03	50.3	0.0	50.3
Sep	2	Deve	1.39	5.74	57.4	0.0	57.4
Sep	3	Deve	1.71	5.77	57.7	0.0	57.7
Oct	1	Mid	1.89	4.80	48.0	0.0	48.0
Oct	2	Mid	1.89	3.31	33.1	0.0	33.1
Oct	3	Mid	1.89	2.84	31.2	0.0	31.2
Nov	1	Mid	1.89	2.43	24.3	0.0	24.3
Nov	2	Late	1.62	1.63	16.3	0.0	16.3
Nov	3	Late	1.14	1.04	10.4	0.0	10.4
Dec	1	Late	0.78	0.64	3.2	0.0	3.2
					479.5	0.0	479.5

Figure 13. Water Demand (CropWAT)

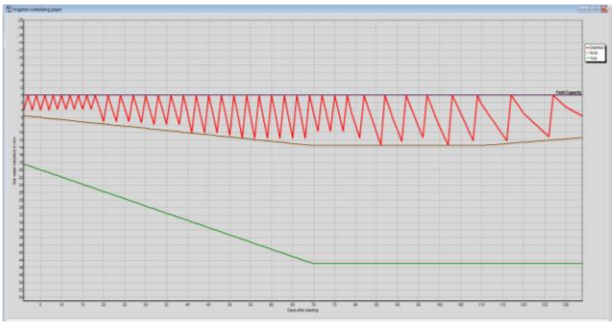
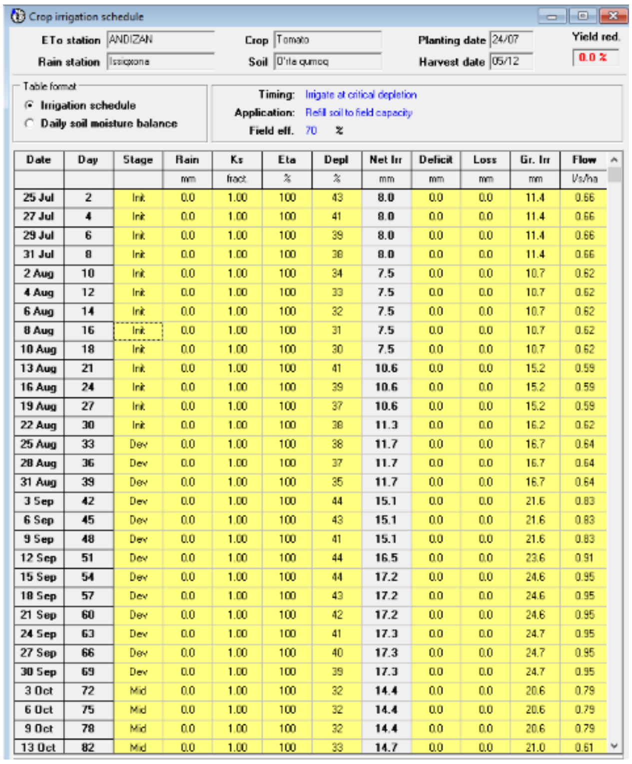


Figure 14. Crop Watering Schedule Graph (CropWAT)

Greenhouse conditions, tomato plants were irrigated using drippers based on FAO's CropWAT program. The level of salinity of the soil, the indicator of digging and not digging, the layout of the seedlings, the duration of light and the temperature provided have a significant effect on the water consumption of the plant [10].

In the conditions of soil salinity level of 4 ds/m, it was required to give more water to the plant. As a result of irrigation water, the salts in the soil slowly fell to the lower layers. In greenhouses with dug soil, less evaporation was observed than in undigged conditions, which in turn indicates the plant's water consumption requirement. Irrigation water given to tomato plants in dug conditions was used 180-220 m^3 less than in unexcavated conditions.



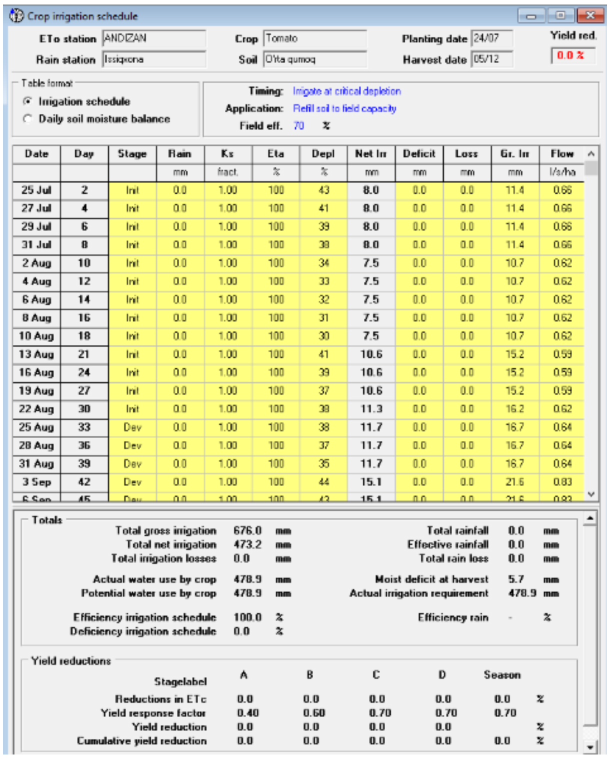
Crop irrigation schedule

ETo station: ANDIZAN; Rain station: Issiqxona; Crop: Tomato; Soil: O'rta qumoq; Planting date: 24/07; Harvest date: 05/12; Yield red.: 0.0 %

Table format: Irrigation schedule / Daily soil moisture balance

Timing: Irrigate at critical depletion; Application: Refill soil to field capacity; Field eff. 70 %

Date	Day	Stage	Rain	Ks	Eta	Depl	Net Irr	Deficit	Loss	Gr. Irr	Flow
			mm	fract.	%	%	mm	mm	mm	mm	l/s/ha
25 Jul	2	Init	0.0	1.00	100	43	8.0	0.0	0.0	11.4	0.66
27 Jul	4	Init	0.0	1.00	100	41	8.0	0.0	0.0	11.4	0.66
29 Jul	6	Init	0.0	1.00	100	39	8.0	0.0	0.0	11.4	0.66
31 Jul	8	Init	0.0	1.00	100	38	8.0	0.0	0.0	11.4	0.66
2 Aug	10	Init	0.0	1.00	100	34	7.5	0.0	0.0	10.7	0.62
4 Aug	12	Init	0.0	1.00	100	33	7.5	0.0	0.0	10.7	0.62
6 Aug	14	Init	0.0	1.00	100	32	7.5	0.0	0.0	10.7	0.62
8 Aug	16	Init	0.0	1.00	100	31	7.5	0.0	0.0	10.7	0.62
10 Aug	18	Init	0.0	1.00	100	30	7.5	0.0	0.0	10.7	0.62
13 Aug	21	Init	0.0	1.00	100	41	10.6	0.0	0.0	15.2	0.59
16 Aug	24	Init	0.0	1.00	100	39	10.6	0.0	0.0	15.2	0.59
19 Aug	27	Init	0.0	1.00	100	37	10.6	0.0	0.0	15.2	0.59
22 Aug	30	Init	0.0	1.00	100	38	11.3	0.0	0.0	16.2	0.62
25 Aug	33	Dev	0.0	1.00	100	38	11.7	0.0	0.0	16.7	0.64
28 Aug	36	Dev	0.0	1.00	100	37	11.7	0.0	0.0	16.7	0.64
31 Aug	39	Dev	0.0	1.00	100	35	11.7	0.0	0.0	16.7	0.64
3 Sep	42	Dev	0.0	1.00	100	44	15.1	0.0	0.0	21.6	0.83
6 Sep	45	Dev	0.0	1.00	100	43	15.1	0.0	0.0	21.6	0.83
9 Sep	48	Dev	0.0	1.00	100	41	15.1	0.0	0.0	21.6	0.83
12 Sep	51	Dev	0.0	1.00	100	44	16.5	0.0	0.0	23.6	0.91
15 Sep	54	Dev	0.0	1.00	100	44	17.2	0.0	0.0	24.6	0.95
18 Sep	57	Dev	0.0	1.00	100	43	17.2	0.0	0.0	24.6	0.95
21 Sep	60	Dev	0.0	1.00	100	42	17.2	0.0	0.0	24.6	0.95
24 Sep	63	Dev	0.0	1.00	100	41	17.3	0.0	0.0	24.7	0.95
27 Sep	66	Dev	0.0	1.00	100	40	17.3	0.0	0.0	24.7	0.95
30 Sep	69	Dev	0.0	1.00	100	39	17.3	0.0	0.0	24.7	0.95
3 Oct	72	Mid	0.0	1.00	100	32	14.4	0.0	0.0	20.6	0.79
6 Oct	75	Mid	0.0	1.00	100	32	14.4	0.0	0.0	20.6	0.79
9 Oct	78	Mid	0.0	1.00	100	32	14.4	0.0	0.0	20.6	0.79
13 Oct	82	Mid	0.0	1.00	100	33	14.7	0.0	0.0	21.0	0.61



Crop irrigation schedule

ETo station: ANDIZAN; Rain station: Issiqxona; Crop: Tomato; Soil: O'rta qumoq; Planting date: 24/07; Harvest date: 05/12; Yield red.: 0.0 %

Table format: Irrigation schedule / Daily soil moisture balance

Timing: Irrigate at critical depletion; Application: Refill soil to field capacity; Field eff. 70 %

Date	Day	Stage	Rain	Ks	Eta	Depl	Net Irr	Deficit	Loss	Gr. Irr	Flow
			mm	fract.	%	%	mm	mm	mm	mm	l/s/ha
25 Jul	2	Init	0.0	1.00	100	43	8.0	0.0	0.0	11.4	0.66
27 Jul	4	Init	0.0	1.00	100	41	8.0	0.0	0.0	11.4	0.66
29 Jul	6	Init	0.0	1.00	100	39	8.0	0.0	0.0	11.4	0.66
31 Jul	8	Init	0.0	1.00	100	38	8.0	0.0	0.0	11.4	0.66
2 Aug	10	Init	0.0	1.00	100	34	7.5	0.0	0.0	10.7	0.62
4 Aug	12	Init	0.0	1.00	100	33	7.5	0.0	0.0	10.7	0.62
6 Aug	14	Init	0.0	1.00	100	32	7.5	0.0	0.0	10.7	0.62
8 Aug	16	Init	0.0	1.00	100	31	7.5	0.0	0.0	10.7	0.62
10 Aug	18	Init	0.0	1.00	100	30	7.5	0.0	0.0	10.7	0.62
13 Aug	21	Init	0.0	1.00	100	41	10.6	0.0	0.0	15.2	0.59
16 Aug	24	Init	0.0	1.00	100	39	10.6	0.0	0.0	15.2	0.59
19 Aug	27	Init	0.0	1.00	100	37	10.6	0.0	0.0	15.2	0.59
22 Aug	30	Init	0.0	1.00	100	38	11.3	0.0	0.0	16.2	0.62
25 Aug	33	Dev	0.0	1.00	100	38	11.7	0.0	0.0	16.7	0.64
28 Aug	36	Dev	0.0	1.00	100	37	11.7	0.0	0.0	16.7	0.64
31 Aug	39	Dev	0.0	1.00	100	35	11.7	0.0	0.0	16.7	0.64
3 Sep	42	Dev	0.0	1.00	100	44	15.1	0.0	0.0	21.6	0.83

Totals

Total gross irrigation	676.0	mm	Total rainfall	0.0	mm
Total net irrigation	473.2	mm	Effective rainfall	0.0	mm
Total irrigation losses	0.0	mm	Total rain loss	0.0	mm
Actual water use by crop	478.9	mm	Moist deficit at harvest	5.7	mm
Potential water use by crop	478.9	mm	Actual irrigation requirement	478.9	mm
Efficiency irrigation schedule	100.0	%	Efficiency rain	-	%
Deficiency irrigation schedule	0.0	%			

Yield reductions

Stagelabel	A	B	C	D	Season	
Reductions in ETc	0.0	0.0	0.0	0.0	0.0	%
Yield response factor	0.40	0.60	0.70	0.70	0.70	
Yield reduction	0.0	0.0	0.0	0.0		%
Cumulative yield reduction	0.0	0.0	0.0	0.0	0.0	%

Figure 15. Crop Watering Schedule (CropWAT)

Tomato plants were irrigated according to the CropWAT program in the initial (before flowering), development (flowering), middle (harvest) and late (ripening) phases. In the initial (before flowering) period, the upper root layer of the soil was constantly supplied with moisture for 25 days. During the period of development (flowering), moisture in a layer of 0,40 m was provided by watering every 3-5 days for 35 days. During the middle (harvest) period, it was irrigated for 35 days. During the last (harvest) period, moisture was provided in the soil layer of 0,4-0,5 meters and irrigated in 8-12 days in order to cook and harvest all the crops [5; 6] .

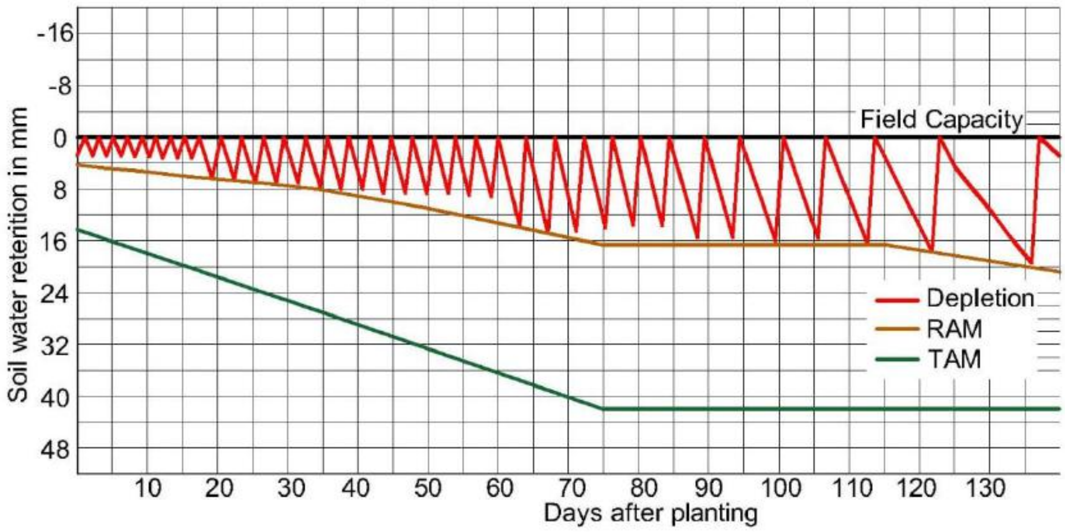


Figure 16. Watering procedure of tomato plant in unexcavated conditions (2018-2019 year)

In dug conditions, in the initial phase, the upper 0-0,2 m layer of the soil is supplied with moisture every 3-5 days for 25 days, while in the development phase, to provide moisture in the layer of 0,4 m for 35 days watered. In the middle (harvest) phase, it was watered every 4-5 days to ensure moisture in the 0.4 m layer. In the last (ripening) phase, it was irrigated for 6-8 days in order to fully ripen and harvest the crop. The FAO method was used to develop the irrigation schedule.

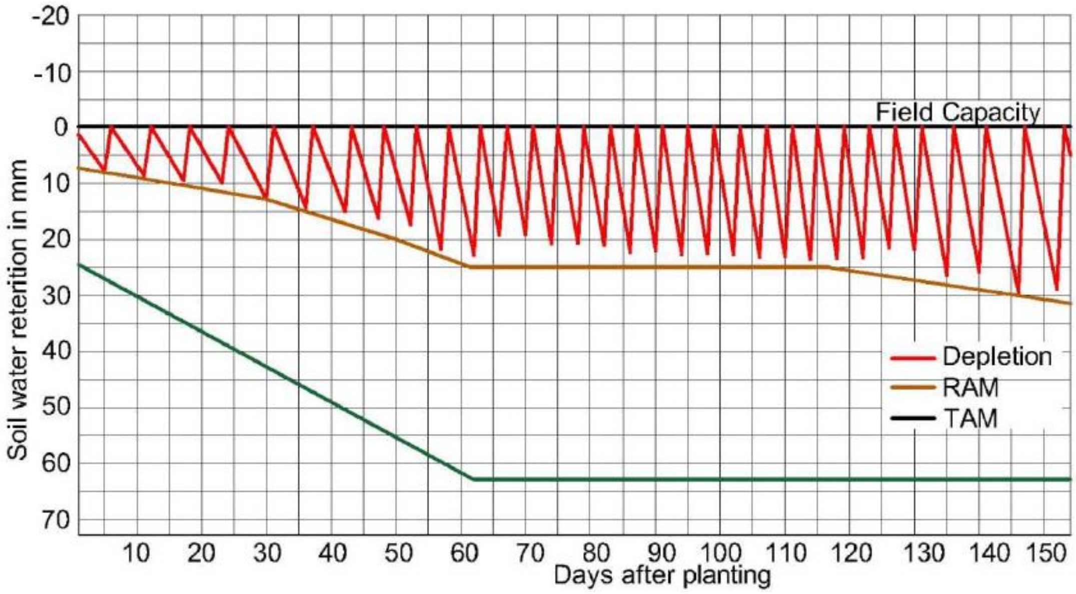


Figure 17. The procedure for watering a tomato plant in dug conditions (**2018-2019 year)**

Seedlings were irrigated based on FAO's CropWAT program using drip irrigation technique [13; 18], economy of heat energy and water resources was achieved in the conditions of digging 0,75-1 m. Seasonal irrigation rates decreased from 4500-5000 m^3/ha to 3500-4000 m^3/ha. 4510-5012 m^3/ha of water was consumed in the traditional method, while 3510-4015 m^3/ha of water was consumed as a result of using fractional factors. Irrigation water was saved by 20-22%.

Results of research on the effect of irrigation norm on the productivity of tomato plants

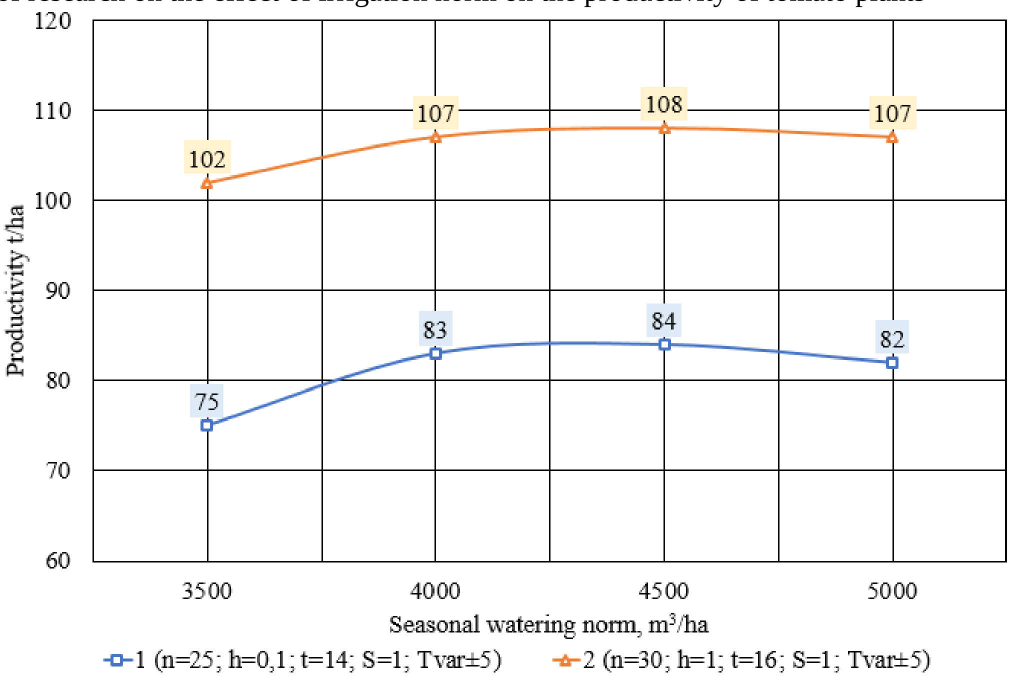


Figure 18. Effect of seasonal irrigation norm on productivity

Among the main factors affecting the cultivation of tomato plants in greenhouse conditions; seasonal irrigation norm (M), soil salinity level (S), excavation depth (h), light duration (t), seedling density (n) and temperature variation (±T_{var}) effect on productivity (Y) was studied. Also, the influence of the seasonal irrigation norm on these factors was studied [20]. Factor 1, the effect of irrigation norm on tomato plant yield was studied (Fig. 3). Drip irrigation was used to irrigate the tomato plant. Option 1 (n= 25 thousand tubs/hectare; h= 0,1 m; t= 14 hours/day; S = 1 ds/m; T_{var} = ±5 °C change) 3500 m^3/ha of water yield was 75 t/ha when given, 83 t/ha when given 4000 m^3/ha of water, 84 t/ha when given 4500 m^3/ha of water, 82 t/ha when given 5000 m ^{3} /ha of water. Option 2 (n=30 thousand tubs/hectare; h-1.0 m; t-16 hours/ day ; S = 1 ds/m; T_{var} = ±5 ºC) 102 t/ha, 4000 m^3/ha - 107 t/ha, 4500 m^3/ha - 108 t/ha, 5000 m^3/ha - 107 t/ha. The highest productivity was achieved due to the method of planting in the 2nd option and the depth of the greenhouse.

Effect of soil salinity on tomato plant productivity and water consumption

A. Chernyshov conductometer based on the Scientific Research Institute of Irrigation and Water Problems (SRIIWP) method of salinity level of greenhouse soils [6] was determined using. Experiments were conducted in a non-saline and low-saline greenhouse [15]. Option 1 (M = 5000 m^3/ha; h = 0,1 m; t = 14 hours/day; n= 25 thousand tubs/hectare; T_{var} = ±5 ºC change) 83 t in non-saline conditions /ha, with weak salinization - yield was 68 t/ha. Option 2 (M = 5000 m^3/ha; h = 1 m; t = 16 hours/day; n= 30 thousand tubs/hectare; T_{var} = ±5 ºC change) in non-saline conditions - 104 t/ha, in weak saline conditions - yield was 86 t/ha. Tomato plant water consumption was studied in non-saline and weakly saline (4 ds/m) soils of greenhouse conditions. Option 3 (n= 30 thousand tubs/hectare; h = 0,1 m; t = 14 hours/day; T_{var} = ±10 ºC change) 4129 m^3/ha in unexcavated and unsalted conditions, weak sho under the conditions - 4421 m^3/ha. Option 4 (n= 30 thousand tubs/hectare; h = 1 m; t = 14 hours/day; T_{var} = ±10 ºC change) excavation depth is 1 m and 4014 m^3/ha in non-saline conditions , in weak saline conditions - was 4238 m^3/ha.

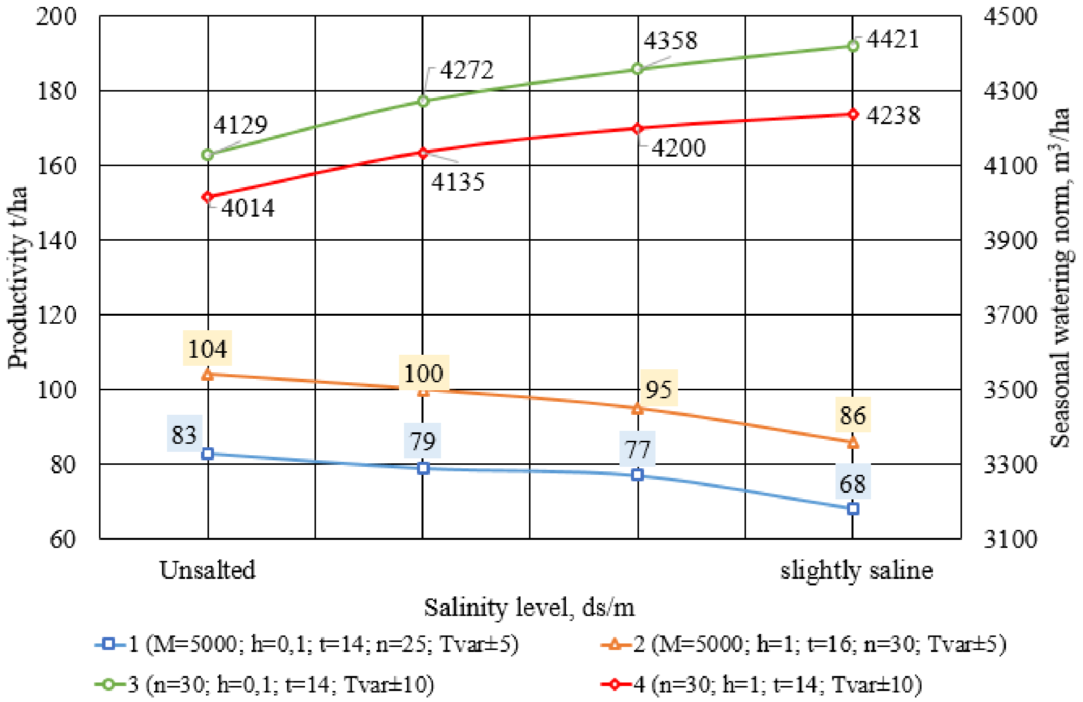


Figure 19. Tomato plant of soil salinity productivity and impact on water consumption

In the 4th option, it was found that 115 m^3/ha less water was consumed in non-saline conditions, and 183 m^3/ha less in weak salinity conditions.

Effect of greenhouse depth on tomato plant productivity and water consumption.

The bottom of the greenhouse was studied in unexcavated and excavated conditions (Fig. 20). Productivity in the greenhouse made on the soil in option 1 (M=5000 m^3/ha; t=14 hours/day; S=1 ds/m; T_{var} =±5 ºC change; n=25 thousand tubs/hectare) 84 t/ha, 105 t/ha in 0,5 m dug greenhouse, 107 t/ha in 1,0 m dug greenhouse, 102 t/ha in 1,5 m dug greenhouse. Productivity in a greenhouse made on soil in option 2 (M=5000 m^3/ha; t=15 hours/day; S=1 ds/m; T_{var} =±5 ºC change; n=30 thousand tubs/hectare) 73 t/ha, 91 t/ha in 0,5 m dug greenhouse, 92 t/ha in 1,0 m dug greenhouse, 86 t/ha in 1,5 m dug greenhouse. Option 3 (M=5000 m ^{3}/ha; t=16 hours/day; S=1 ds/m; T_{var} =±5 ºC change; n=35 thousand tubs/hectare). The productivity in the greenhouse made around 0-10 cm above the soil is 95 t/ha, in the greenhouse dug 0,5 m 118 t/ha, in the greenhouse dug 1,0 m 119 t/ha, in the greenhouse dug 1,5 m the yield is 111 t/ha did Productivity in the greenhouse made on the soil in option 4 (M=5000 m^3/ha; t=16 hours/day; S=1 ds/m; T_{var} =±5 ºC change; n=40 thousand tubs/hectare) 101 t/ha, 121 t/ha in 0,5 m dug greenhouse, 123 t/ha in 1,0 m dug greenhouse, 114 t/ha in 1,5 m dug greenhouse. It was found that energy efficiency is high in earth-excavated greenhouses due to the saving of energy resources in the heating and cooling of greenhouses dug up to 0,5-1,0 m.

INTERNATIONAL JOURNAL FOR INNOVATIVE RESEARCH IN MULTIDISCIPLINARY FIELD
ISSN(O): 2455-0620 [Impact Factor: 9.47]
Monthly, Peer-Reviewed, Refereed, Indexed Journal with IC Value : 86.87
Volume - 10, Issue - 8, August - 2024

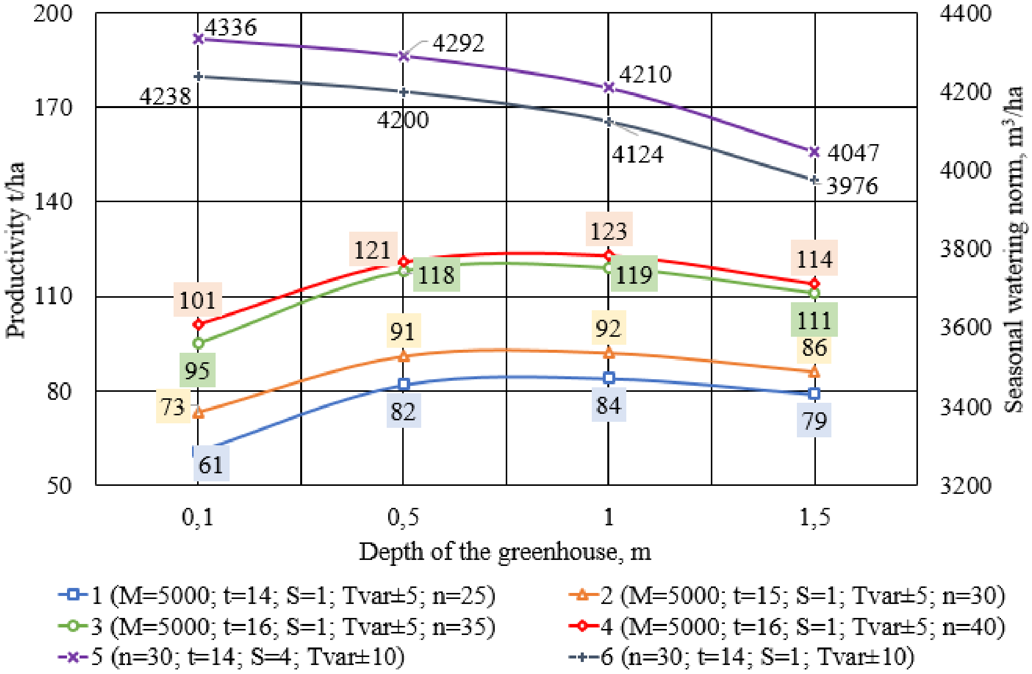


Figure 20. Effect of greenhouse depth on yield and water use of tomato plants

The water consumption of tomato plants was studied according to the digging depth of greenhouse conditions. Excavation in weakly saline (4 ds/m) conditions in option 5 (n= 30,000 tubs/hectare; t = 14 hours/day; S=4 ds/m; T_{var} = ±10 ºC change) when the depth is 0,1 m, the seasonal irrigation norm is 4336 m^3/ha, 0,5 m - 4292 m^3/ha, 1,0 m - 4210 m^3/ha and 1,5 m - 4047 m It was^3/ha. Option 6 (n= 30 thousand tubs/hectare; t = 14 hours/day; S=1 ds/m; T_{var} = ±10 ºC change) when the digging depth is 0,1 m in non-saline conditions, seasonal irrigation norm was 4238 m^3/ha, 0,5 m - 4200 m^3/ha, 1,0 m - 4124 m^3/ha and 1,5 m - 3976 m^3/ha. When the 5th and 6th options are compared, the difference between the seasonal irrigation standards is 98 m^3/ha when the digging depth is 0,1 m, 0,5 m - 92 m^3/ha, 1,0 m - 86 m^3/ha and 1,5 m – 71,0 m^3/ha of water were used. Although less water was consumed when the soil depth was 1,5 m, it was found that the efficiency of light and heat energy was at 1,0 m depth.

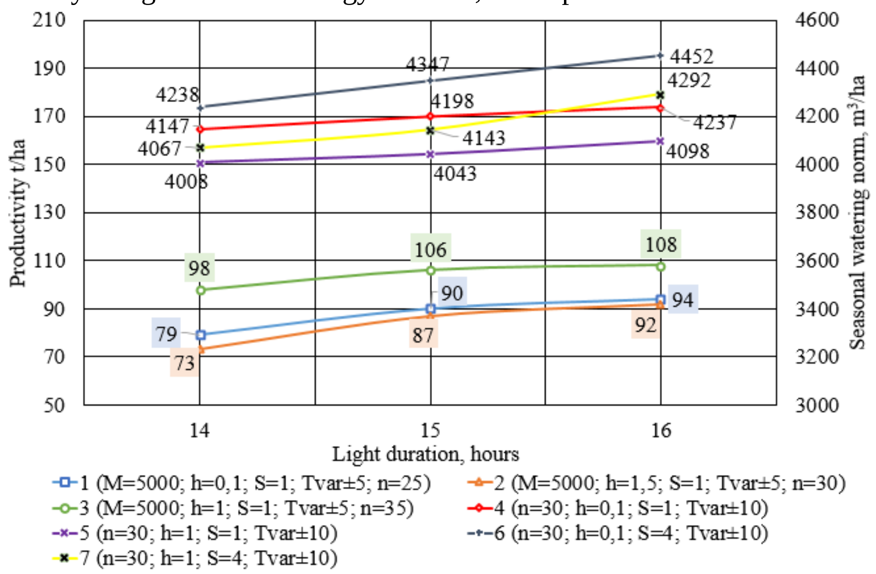


Figure 21. Effects of photoperiod duration on yield and water consumption of tomato plants

Effects of photoperiod duration on tomato plant productivity and water consumption. In greenhouse conditions, the duration of light was increased by using diode lamps from artificial light sources and the effect on yield was studied (Fig. 21). In this case, 8 diode lamps were placed on an area of 20 m^2, providing the same light flow distribution to the plants. In option 1 (M=5000 m^3/ha; h=0,1 m; S=1 ds/m; T_{var}=±5 ºC change; n=25 thousand tubs/hectare) with natural light At the same time, the yield was 73 t/ha when 14 hours/day of light was provided. 87 t/ha when 15 hours/day was provided, and 92 t/ha when 16 hours/day was provided. Option 2 (M=5000 m^3/ha; h=1,5 m; S=1 ds/m; T_{var} = ±5 ºC change; n=30 thousand tubs/hectare) 14 hours/day light In the period of 2016, the productivity was 79 t/ha, 90 t/ha at 15 hours/day, 94 t/ha at 16 hours/day. In option 3 (M=5000 m^3/ha; h=1 m; S=1 ds/m; T_{var} = ±5 °C change; n=35 thousand tubs/hectare) in 14 hours/day light 98 t/ha, 106 t/ha at 15 hours/day and 108 t/ha when provided with additional light for 16 hours/day. Let's see if option 3 is effective in terms of productivity possible In the 4th option (n=30 thousand tubs/hectare; h=0,1 m; S=1 ds/m; T_{var} = ±10 °C change) the light duration is 14 hours/ The standard of seasonal irrigation was 4147 m^3/ha when provided daily, 4198 m^3/ha at 15 hours/day , and 4237 m^3/ha at 16 hours/day . Excavation depth in option 5 (n=30 thousand tubs/hectare; h=1 m; S=1 ds/m; T_{var} = ±10 °C change) [26] 1,0 m, 4008 m^3/ha at 15 h/day at 14 h/day light duration under non-saline conditions 4043 m^3/ha, at 16 hours/ day - 4098 m^3/ha of water was consumed. Option 6 (n= 30 thousand tubs/hectare; h=0,1 m; S=4 ds/m; Tchek= ±10 °C change) in unexcavated, weak saline conditions, 14 hours/day 4238 m^3/ha, 15 hours/day in light duration - 4347 m^3/ha, at 16 hours/day - 4452 m^3/ha of water was consumed. Option 7 (n=30 thousand tubs/hectare; h=1 m; S=4 ds/m; Tchek= ±10 °C change) dug 1,0 m in weak saline conditions, 14 hours/day 4067 m^3/ ha at 15 hours/day - 4143 m^3/ha, at 16 hours/day It consumed 4292 m^3/ha of water. As the duration of light increases, energy costs increase. Therefore, at 14 hours/ day It was determined that tomato plant water consumption is lower than other options in options 5-7 for light continuity, non-saline and weakly saline conditions [21; 26].

Effect of plant density on yield and water consumption of tomato plants

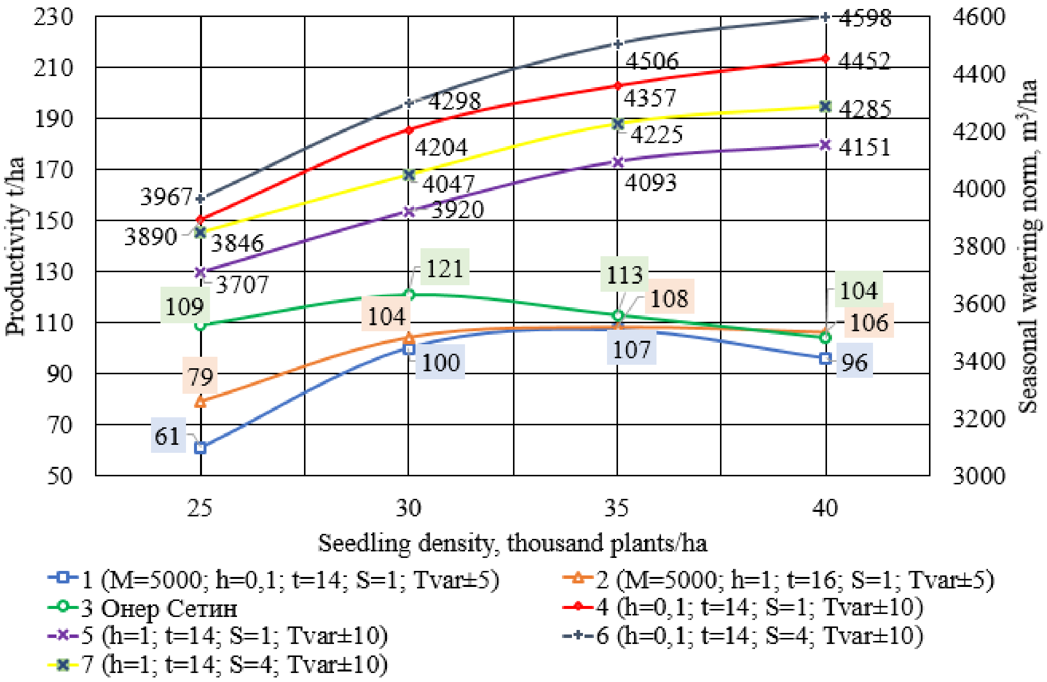


Figure 22. Effect of planting density on yield and water use of tomato plants

The number of tomato seedlings per 1 ha area was studied (in Figure 22). In option 1 (M=5000 m^3/ha; h=0,1 m; t=14 hours/day; S=1 ds/m; Tchek=±5 °C change) under conditions made on soil the number of chats is 61 t/ha for 25 thousand bushes/ha, 100 t/ha for 30 thousand bushes/ha, 107 t/ha for 35 thousand bushes/ha, 96 t/ha for 40 thousand bushes/ha, organized. Option 2 (M=5000 m^3/ha; h=1 m; t=16 hours/day; S=1 ds/m; Tchek=±5 °C change) i.e. soil 1,0 m the number of seedlings corresponding to 1 in the conditions dug in the depth is 79 t/ha for 25,000 bushes/ha, 104 t/ha for 30,000 bushes/ha, 108 t/ha for 35,000 bushes/ha, 40,000 bushes/ha yield was 106 t/ha. In the studies of Professor Oner Setin (Turkey), 25 thousand bushes/ha - 109 t/ha, 30 thousand bushes/ha - 121 t/ha, 35 thousand bushes/ha - 113 t/ha and 40 thousand bushes/ha - 104 t/ha organized productivity [23]. The water requirement of the tomato plant in the greenhouse depends on the density of the seedlings, among other factors. Option 4 (h=0,1 m; t=14 hours/day; S=1 ds/m; T_{var} = ±10 °C change) when 25,000 seedlings per hectare , 3890 m^3/ha, 4204 m^3/ha for 30 thousand seedlings , 4357 m^3/ha for 35 thousand seedlings and 4452 m^3/ha for 40 thousand seedlings . In option 5 (h=1 m; t=14 hours/day; S=1 ds/m; T_{var} = ±10 °C change), when 25 thousand seedlings per hectare correspond to 3707 m^3/ha, 3920 m^3/ha for 30 thousand seedlings, 4093 m^3/ha for 35 thousand seedlings and 4151 m^3/ha for 40 thousand seedlings . Option 6 (h=0,1 m; t=14 hours/day; S=4 ds/m; T_{var} = ±10 °C change) unexcavated greenhouse, 25 thousand bushes per 1 hectare in weak saline conditions according to chat, 3967 m^3/ha, 30 thousand bushes - 4298 m^3/ha, 35 thousand bushes - 4506 m^3/ha and 40 thousand bushes - 4598 m^3/ha water was consumed. Option 7 (h=1 m; t=14 hours/day; S=4 ds/m; T_{var} = ±10 °C change) soil 1,0 meter dug greenhouse, 1 by 25 thousand in weak saline conditions 3846 m^3/ha per bush, 4047 m^3/ha in

30 thousand bushes, 4225 m^3/ha in 35 thousand bushes and 4285 m^3 in 40 thousand bushes/ha of water was consumed.

As the number of seedlings increases, water consumption also increases, but the yield does not necessarily increase. We can see that the option corresponding to 30-35 thousand bush/ha is acceptable due to the fact that human movement is regularly observed among the seedlings. The number of tomato seedlings per 1 ha area was studied. In the 1st option (h-0,1 m), i.e., in the conditions on the ground, the number of tomato seedlings is 104 t/ha for 25 thousand pieces/ha, 143 t/ha for 30 thousand bushes/ha, 35 150 t/ha for 1,000 bushes/ha, 139 t/ha for 40,000 bushes/ha. In the 2nd option, i.e., in the condition that the soil is dug to a depth of 1 m, the number of seedlings corresponding to 1 is 25 thousand bushes/ha 122 t/ha, 30 thousand bushes/ha 147 t/ha, 35 thousand bushes/ha

Effect of temperature changes on yield and water consumption of tomato plants

The effect of temperature on productivity in greenhouse conditions is considered one of the important factors [11,12].

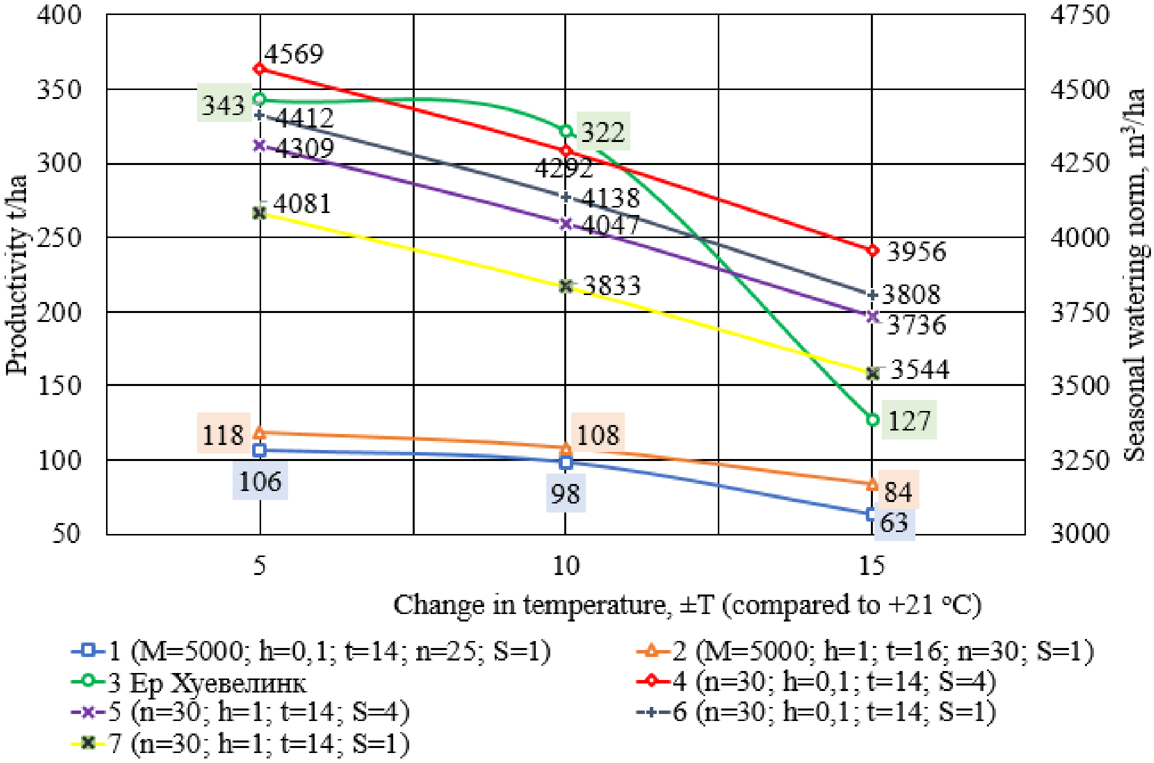


Figure 23. Effects of temperature variation on yield and water consumption of tomato plants

The night temperature +14 ºC and the daytime temperature +28 ºC are considered favorable conditions for the tomato plant, and we took the average as +21 ºC. Option 1 (M=5000 m^3/ha; h=0,1 m; t=14 hours/day; n=25 thousand bushes/ha; S=1 ds/m) T_{var} ±5 ºC 106 t/ha, T_{var} ±10 º C 98 t/ha, T_{var} ±15 ºC 63 t/ha. Option 2 (M=5000 m^3/ha; h=1 m; t=16 hours/day; n=30 thousand bush/ha; S=1 ds/m) T_{var}±5 ºC 118 t/ha , T_{var} ±10 ºC 108 t/ha, T_{var} ±15 ºC 84 t/ha, yield was obtained. 3 - According to the results obtained from the research of Yer Huyevelink (Netherlands), the yield was 343 t/ha when T_{var} ±5 ºC, 322 t/ha at T_{var} ±10 ºC, and 127 t/ha at T_{var} ±15 ºC. Keeping the temperature around +21 ºC T_{var}±5 ºC during the growing season is difficult and requires additional funds. Therefore, it was found that economic efficiency is high when Tchek changes around ±10 ºC. In option 2, since 1,0 m of soil was excavated, it was possible to save heating resources in winter months and ventilation resources in summer months. In greenhouse conditions, water consumption by the tomato plant increased as the temperature increased. Option 4 (n=30 thousand bush/ha; h=0,1 m; t=14 hours/day; S=4 ds/m) in unexcavated, weakly saline conditions, the temperature is +21 ºC ± 5 ºC when changed, 4569 m^3/ha, when ±10 ºC changed 4292 m^3/ha, when ±15 ºC changed 3956 m^3/ha of water was consumed. In option 5 (n=30 thousand bushes/ha; h=1 m; t=14 hours/day; S=4 ds/m) the soil is excavated 1,0 m, ±5 ºC in weakly saline conditions 4309 m^3/ha when changing, 4047 m^3/ha when changing ±10 ºC, 3736 m^3/ha when changing ±15 ºC was consumed. Option 6 (n=30 thousand bush/ha; h=0,1 m; t=14 hours/day; S=1 ds/m) in non-excavated, non-saline conditions 4412 m^3/ha, 4138 m^3/ha when changing ±10 ºC, 3808 m^3/ha when changing ±15 ºC. In option 7 (n=30 thousand bushes/ha; h=1 m; t=14 hours/day; S=1 ds/m) the soil is excavated by 1,0 m, when ±5 ºC changes in non- saline conditions Water consumption was 4081 m^3/ha, 3833 m^3/ha when changing ±10 ºC, 3544 m^3/ha when changing ±15 ºC. The price of the product does not pay for itself due to the high energy costs used to maintain the temperature in the greenhouse at ±5 ºC. Therefore, it was reasoned that the yield and water consumption at a change of ±10 º C is acceptable and the use of options 5-7 is appropriate [24]. Currently, developed countries are predicting the yield of tomato plants based on genetic algorithms and wavelet neurons. Such results were obtained by Y. Wang, R. Xiao and others from the scientists of the People's Republic of China (PRC) [28].

Evapotranspiration is equal to the total sum of transpiration from the soil surface and plant evaporation. According to FAO manual 24, the amount of evapotranspiration can be determined using evaporites and formulas.

When determining the standard evapotranspiration value (EET_0) of plants, the plant is not diseased, the soil fertility is excellent, and all the conditions for the growth and development of the plant are normal, such as irrigation, sunlight, and climate. , the evaporation from the 8-12 cm grown standard plant (a lawn with a full surface) is understood [27]. On the basis of field experiments, standard evapotranspiration values were determined using "A" type evaporator (Figure 3.8.1) and on the basis of the following formulas:

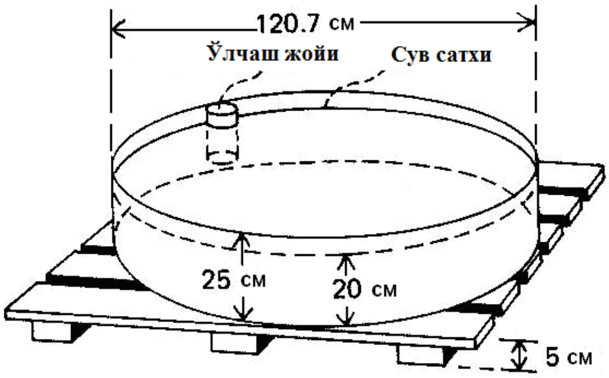


Figure 24. Construction and appearance of type "A" evaporator

$$ET_0 = k_r E_0 \quad (3.8.1)$$

In this case , K_r – is the coefficient of the evaporator, depending on the location of the structure, it varies in the range of 0,35-0,85, ET_o – is the water evaporated from the evaporator, mm.

Greenhouse conditions were defined as evapotranspiration, which evaporates from the indoor area where tomato plants are grown:

$$ET_C = k_C ET_0 \quad (3.8.2)$$

Here: k_s is the coefficient taking into account the growth period of the tomato plant.

Once a day, every day at 9:00 a.m., the amount of water evaporated from the "A" type evaporator used in greenhouse conditions was determined and recorded. As a result, water demand was studied and compared with the Penmann-Montey method. We can see that the difference between them does not exceed 5-6% [2; 5; 18; 25].

1 – table

Table of comparison with FAO method (2017-2020)

The date	**T- air temperature**		**Air humidity, %**		**u_2 - wind speed, m/s**	**Penmann-Monteita method**	**This is the vaporizer**	**Difference, %**
	Maximum	Minimum	Maximum	Minimum				
11.01.2020	12,3	9,2	98	91	1,36	0,70	0,7	-3,7
06.02.2020	14,6	7,9	89	38	3,4	5,08	5,3	4,3
18.03.2020	19,5	4,9	94	36	2,45	6,81	7,2	6,1
20.04.2020	14,9	5,1	91	54	3,33	3,99	4,0	1,4
05/03/2020	19,2	8,5	91	57	3,08	4,84	5,0	2,8
08.06.2020	26,8	11,6	89	46	3,39	9,16	9,7	5,7
11.07.2020	35,7	15	79	26	2,74	20,01	20,8	3,7
18.08.2020	31,7	13	87	25	2,62	16,01	15,1	-5,6

21.09.2020	39,3	16,2	52	11	1,31	28,64	29,8	3,9
03.10.2020	25,9	11,2	89	43	1,84	8,91	9,3	4,1
04.11.2020	16,3	5,7	87	45	1,45	5,07	5,3	5
22.12.2020	12,1	6,9	97	83	2,73	1,24	1,3	3,1

4. CONCLUSION:

- Researches were carried out in greenhouse conditions in the farms of Andijan and Tashkent regions. Experiments were carried out in greenhouses excavated in places where the water table (SSS) is below 4-5 meters, and in the conditions where the SSS is up to 3 meters. One of the main reasons for this is that the capillary rise reaches a height of 2-2,5 meters, which caused several problems in the development of the tomato plant. Therefore, regions with low SSS were selected. The temperature indicators of the external environment were obtained from the ClimWAT program. The temperature indicators of the greenhouse conditions were recorded daily using a thermostat placed stationary at a height of 2 meters above the soil surface and were brought to the monthly average value.
- was conducted in 20 m^2 area, the border between experiments was not less than 5 meters. Experiments were conducted with light duration control, 14 hours, 15 hours and 16 hours. We used energy-efficient LED lights to ensure continuous light. Illuminance was measured using a luximeter (HS1010A digital light meter).
    - Based on the FAO method, irrigation for greenhouse conditions is carried out using special drippers and flexible hoses. Irrigation was carried out through the CropWAT program.
    - Factors affecting the productivity of the tomato plant, structural elements of the greenhouse (seasonal irrigation standards, soil salinity, greenhouse depth, seedling thickness, light period, temperature range) was selected. Based on them, methodological experiments were conducted and the effect of each factor on the tomato plant was evaluated.
- On the basis of conducted methodological experiments, the KOE matrix was created and the table of interaction of factors was formed. A formula was developed that evaluates the effect of seasonal irrigation standards, soil salinity, greenhouse depth, seedling thickness, light period, and temperature variation on the productivity of this tomato plant.
- The applicability of FAO's CropWAT program for greenhouse conditions was justified, and with the help of this program, the irrigation procedure of tomato plant "Lamia F1" was developed. In particular, economy of heat energy and water resources was achieved in the conditions of digging 0,75-1 m. Seasonal irrigation rates decreased from 4500-5000 m^3/ha to 3500-4000 m^3/ha.
- The economic indicators of tomato cultivation in greenhouse conditions were considered and resource-saving structural elements were studied.

REFERENCES:

1. Abutaliev F.B., Baklushin M.B., On the issue of moisture transfer during the inter-irrigation period. Vestnik NUU, T. 2002, 56-88 p.
2. Baklushin M.B., Dudko O.P., Dukhovny V.A., Chulpankulov E.D., on determining the value of transpiration in an agricultural field. Izvestiya AN RU, No. 4, 1974, 47-49 p.
3. Balliu, A., Marsic, N.K., and Gruda, N., FAO Seedling Production 2017, 197–216 p.
4. Bie Y., Li Z., Lei J., Ma Z., Li M., Królczyk G., & Li W. (2020). Solar medium-low temperature thermal utilization and effect analysis of boundary condition: A tutorial. Solar Energy, 197, 238–253. https://doi.org/10.1016/j.solener.2020.01.016
5. Savvinov N.I., Soil conservation and resource-saving agriculture: theory and research methods. Ankara – 2015. FAO 2015. 70-76 p.
6. Chernyshov A.K. Salt concentration meter IKS-Express T Brief description, calibration method for the device, operating and measurement instructions. Tashkent 2010, pp. 21-29.
7. Decree of the President of the Republic of Uzbekistan dated October 23, 2019 No. PF-5853 "On the strategy of agricultural development of the Republic of Uzbekistan for 2020-2030".
8. Hilorme T., Tkach K., Dorenskyi O., Katerna O., & Durmanov A. (2019). Decision making model of introducing energy-saving technologies based on the analytic hierarchy process. Journal of Management Information and Decision Sciences, (4), 489–494 p.

9. Aleksandrova L.S. Growth and absorption activity of tomato plants under artificial lighting // Collection of Works on Agronomic Physics. Issue 15, Leningrad, 1998, 136-142 p.
10. Surendran U., Sushanth C. M., Mammen G., & Joseph E. J. (2017). FAO-CROPWAT model-based estimation of crop water need and appraisal of water resources for sustainable water resource management: Pilot study for Kollam district - humid tropical region of Kerala, India. Current Science, 112(1), 76–86 p. https://doi.org/10.18520/cs/v112/i01/76-86
11. Lee C. G., Cho L. H., Kim S. J., Park S. Y., & Kim D. H. (2021). Comparative analysis of combined heating systems involving the use of renewable energy for greenhouse heating. Energies, 14(20). https://doi.org/10.3390/en14206603
12. Li T., Heuvelink E., Dueck T. A., Janse J., Gort G., & Marcelis L. F. M. (2014). Enhancement of crop photosynthesis by diffuse light: Quantifying the contributing factors. Annals of Botany, 114(1), 145–156. https://doi.org/10.1093/ aob/mcu071.
13. R.A. Muradov, A.N. Ubaydillayev, D.A. Ubaydillayeva. (2023). // Develop a tomato irrigation schedule. *EPRA International Journal of Research and Development (IJRD)*, *8*(6), 67–70. Retrieved from http://www.eprajournals.net/index.php/IJRD/article/view/2214
14. Muradov, R., and A. Ubaydillayev. "Tomatoes Cultivation Under Conditions of a Managed Farming Systems." Bulletin of Science and Practice (2022).
15. Bakuras N.S., Lutsenkova K.K. Greenhouse vegetable growing in Uzbekistan. Tashkent. Mekhnat 1985. 163 p.
16. Ubaydillayev, A. N., et al. "Heat and Energy-Economıc Analysıs for Greenhouses of the Republıc of Uzbekıstan." *International Journal of Advanced Science and Technology* 29.8 (2020): 3285-3298.
17. Avliyakulov M. A., Durdiev N. K., Gopporov F.F., Yakhyoeva N.N. Continuous, year round use of irrigated lands in southern zone of uzbekista Central Asian Problems of Modern Science and Education 4 (2), 125-135 p.
18. Penman M. FAO 56 Definition of ETo 63-81 p.
19. Palmitessa O. D., Paciello P., & Santamaria P. (2020). Supplemental LED increases tomato yield in mediterranean semi-closed greenhouse. Agronomy, 10(9). https://doi.org/10.3390/agronomy10091353
20. Muradov, R.A., Ubaidillaev A.N. // Agricultural technology of tomatoes in the conditions of a controlled agricultural system // "Bulletin of Science and Practice 8.7 (2022): 122-126. https://cyberleninka.ru/article/n/agrotehnika-tomatov-v-usloviyah-upravlyaemoy-sistemy-vedeniya-selskogo-hozyaystva
21. Ubaydillayev A.N. Muradov R.A. // Creating a lighting environment in artificial lighting technologies // EPRA International Journal of Research and Development (IJRD) Volume 7, Issue: 5, Pages 324-331.
22. Ubaydillayev A.N. Dissertation PhD “Development of water and resource – saving technologies for growing tomatoes in greenhouses” Tashkent 2022.
23. Oner Cetin, Demet Uygan. The effect of drip line spacing, irrigation regimes andplanting geometries of tomato on yield, irrigationwater use efficiency and net return. Agricultural Water Management 95(8):949-958. August 2008. 949-959 p.
24. Ubaydillayev A.N. Effect of temperature on tomato plant productivity. Problems of scientific and practical activities. Search and selection of innovative solutions, Issue 978-5-907434-74-5, Pages 96-98. https://elibrary.ru/item.asp?id=47407149
25. Ubaydillayev A.N. Muradov R.A. Modeling of the thermal regime in the conditions of the managed agrosystem. EPRA International Journal of Multidisciplinary Research (IJMR) 2021. https://eprajournals.com/IJMR/article/5768
26. Ubaydillayev A.N. Muradov R.A. // The effect of artificial light on the cultivation of tomato plants // №3 2021.
27. Savvas, D., Ntatsi, G., and Baruchas, P. E., Soil conservation, fertility and plant nutrition management FAO 2017. 288-292 p.
28. Wang Y., Xiao R., Yin Y., & Liu T. (2021). Prediction of tomato yield in chinese-style solar greenhouses based on wavelet neural networks and genetic algorithms. Information (Switzerland), 12(8). https://doi.org/10.3390/info12080336
29. Ciptaningtyas D., Kurniati D., Ulfah N., Aditia R., & Bafdal N. (2017). Pengaruh Water Stress Treatment pada Pertumbuhan dan Produktivitas Tanaman Tomat (Solanum lycoperscium.L) di Wilayah Tropis. Jurnal Teknotan, 11(2), 34. https://doi.org/10.24198/jt.vol11n2.4
30. Yekaterina Lyan. Abdusamat Ubaydillaev, Rustam Muradov // Seasons and effectiveness of using greenhouses in Uzbekistan // Agro science #6 2019 http://qxjurnal.uz/load/jurnal_2019/agro_ilm_2019_jil_6_ilova_63/8-1-0-449