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Methodology for Calculating Maximum Income in the Greenhouse Economy

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Abstract. With the transition to market relations in conditions of free pricing, a rapid rise in prices for material and energy resources began. All this made it difficult to use greenhouses. The main problem in the production of off-season vegetables is their high cost due to significant energy costs. The share of energy costs reaches 60% in the structure of the cost of greenhouse vegetable production. The primary task of greenhouse vegetable growing is to eliminate seasonality in the production of vegetables and provide the population with vegetables at scientifically sound standards and affordable prices. A prerequisite for solving this problem is to increase the efficiency of greenhouse vegetable growing, which implies an increase in vegetable production and a reduction in their cost. The main goal of the study is to develop effective directions and economic mechanisms for increasing the efficiency of greenhouse vegetable production, primarily through the use of advanced energy and resource-saving technologies. When performing the research work, statistical, monographic, calculation-constructive and economic-mathematical methods of research with the use of computers were used. The economic analysis was carried out by the following methods: comparison of actual and normative (planned) indicators; index, to determine the rate of growth or increase in indicators; graphic, for visual representation of the scale, dynamics, with the texture of all processes; correlation, multidimensional analysis of changes in generalized indicators under the influence of various factors.

INTRODUCTION

After the intensive development of closed pound vegetable growing in the 80s, the industry is currently in a recession. The production of products in most greenhouse complexes is unprofitable. In order to preserve the existing potential and ensure the further development of the industry in the current economic conditions, it is necessary to improve the directions increasing the efficiency of greenhouse vegetable growing [1,2]. When planning and implementing measures to improve the efficiency of vegetable production in greenhouses in modern conditions, it is necessary to take into account the features of greenhouse vegetable growing, which predetermine the features of assessing economic efficiency [3,4].

The use of modern substrates for jumping out of vegetable crops suggests that land, as the main means of production, for greenhouse vegetable growing is not decisive. Consequently, for greenhouse vegetable growing, specific performance indicators per 1, we are deprived of economic content, their it is more expedient to determine per 1 kg of vegetable products [5].

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The presence of artificial lighting and heating has a huge impact on increasing the productivity of vegetable crops in greenhouses.

Consequently, the determination of the indicators of the specific consumption of energy resources in the study of the production efficiency of off-season vegetables is mandatory.

In greenhouse vegetable growing at the present time, due to the development of new technologies, the growing season of vegetable crops has significantly expanded [6]. The speed of the production process in different periods of the growing season will be different, which must be taken into account when analyzing the efficiency of vegetable production,

The collection and sale of off-season vegetable products are stretched over time, which is why the selling prices for vegetables at the beginning and at the end of the period of nakedness differ significantly. In this situation, the use of seasonal indicators of the efficiency of vegetable production will give a clearer picture of the results of the enterprise.

The sectoral feature of greenhouse vegetable growing determines the search for ways to increase economic efficiency. A large number of factors affect the efficiency of the production of greenhouse vegetables. However, the results of the study of the state of indoor vegetable growing showed that in modern conditions, two factors should be singled out, which will significantly increase the economic efficiency of production: the introduction of intensive technologies for growing vegetables in greenhouses; rational use of energy resources in greenhouse vegetable growing.

Literature review

The theoretical and practical aspects of the development of hydroponics, the issues of specialization and concentration of agricultural production, cost management and the formation of the organizational and economic mechanism of vegetable and horticultural economies were studied by agronomic economists [7]. For instance, Abdullaev & Zuev (2002) devoted their publication to vegetable growing in protected soil [8]. Regional allocation of green houses and their advantages in Uzbekistan are their main contribution emphasizing the importance of the work. Buzdalov (2009) focused on the aspect of forecasting consumer demand for vegetable products of closed ground [9]. The author's findings are essential in the area of mathematical modeling of greenhouse vegetable crops and demand for it in the market. Chazova (2015) approached the forecasting of cycles and crises in overall agricultural products [10]. However, the author produced a generalized forecasting model for agricultural products. Umarov, Durmanov (2019), Nurimbetov (2021), Sharapova (2016), highlighted the issues of innovative irrigation in green houses located in Tashkent Region of Uzbekistan [11,12,13,14]. Silaeva (2015), A. Skachkova (2013), A. Svetlakov (2017) Therefore a need for a particular approach for greenhouse farming is observed through the literature review [15,16,17]. Significant contributions to the area of sustainable development of public production were made by such scientists as, M. Li (2017), V. Nabokov and K. Nekrasov (2017), M. Porter (2006) [18,19,20]. Their findings were used in this research as a basis for mathematical calculations.

METHODOLOGY

Currently, there are no generally accepted methods to predict the development of agricultural production in organizations with satisfactory reliability [21].

It should also be noted that the strengthening of the economic freedom of participants in the reproductive innovation process at the regional level forms a probabilistic picture of organizational and economic processes occurring in different sectors, and forces the use of a scenario approach and multivariate alternative ways of finding solutions [22].

To solve this problem, it is proposed to use the methods of multivariate statistical analysis and economic and mathematical modeling. The changes taking place in the modern economy lead to the creation of new and improved systems that allow analyzing the dynamics of the development of a regional organization and using large volumes of relevant information and economic and mathematical modeling [23].

The methodology of the organizational and economic mechanism for sustainable development of the greenhouse market is based on an integrated and systematic approach [24]. An integrated approach takes into account a set of market factors affecting the management of sustainable development of the greenhouse market. The systematic approach is applied in the study as a general methodological basis [25]. It provides an objective reflection of the systemic properties of the functioning of the greenhouse market players and takes into account a complex of interrelated elements, taking into account the peculiarities of local agriculture, the variability of external and internal factors, the level of state support to meet the requirements. social needs formed by enterprises in the context of constant changes in the elements of the market environment [26].

The inconstancy of the external environment, limited resources, the presence of highly profitable and unprofitable industries in greenhouse farms located in the same natural and economic conditions, do not allow us to determine the only most effective methodological approach [27].

The general theoretical and methodological basis of the research is formed by scientific publications on the problems of the development of the agro-industrial complex and agriculture, in particular the market of greenhouse vegetable crops; analysis of intra-industry competition and increasing the competitiveness of enterprises in modern economic conditions [28].

The study used methods widely used in economic sciences: general scientific (dialectical method, analysis and synthesis, comparisons and analogies, graphic method) [29]; special (economic and mathematical, systemic, statistical and economic, comparative analysis, mathematical modeling and experimental methods).

The information base of the study is made up of official statistical data of the Ministry of Agriculture of the Republic of Uzbekistan; state statistics; normative legal norms of the republican and municipal, regional levels; reference materials of specialized publications on the topic; data received from participants in the greenhouse market, own research; scientific internet data [30, 31].

RESULTS

Our methodology allows us to optimally assign the area of crops with a known deficit of fuel, energy and labor resources, as well as to increase the productivity of irrigation and irrigation water, taking into account the climatic conditions of farms, as well as the biological characteristics of crops.

This problem is solved using the proposed computer model, which is based on the following system of equations:

$G_{\max} = \sum_{i=1}^{N} (P_i - C_i) Y_i F_{iopt}$ - the maximum income from the cultivation of agricultural prospect of induction, sum where P is the value of agricultural products, sum / kg; C - the cost of cultivation agriculture of -agricultural products, UZS / c; U - crop productivity, kg / ha; F - area under.

Restriction of fuel and energy resources is expressed cl e following way:

$$\sum_{i=1}^{N} Q_{iopt} F_{iopt} = K_{\lim} \sum_{i=1}^{N} Q'_{inor} F'_i$$

Here Q $_{iopt}$, Q ' $_{norm}$ - optimized and biologically optimal thermal energy neo b walk for cultivating crop, J; F $_{iopt}$, F ' $_{norm}$ - Adapt and Rowan and planned area crops ha; By $_{\lim}$ –limiting the conductive factor, based on the availability of energy resources.

Limitation in the area:

$$F = \sum_{n=1}^{N} F_i;$$

where the F - total area of Hothouse and greenhouse agriculture under the Agricultural e cult have, ha; The F_i - Square of the area under crops (tomato, cucumber, bell pepper, lemons, Cloud b nickname and roses).

$$\begin{cases} F_{1opt} = f_1 F; \quad Q_1 = w_1 Q; \quad q_1 = \dfrac{Q_1}{F_{1opt}}; \quad Y_1 = Y_{1\max} \cdot \left[1 - \dfrac{q_1}{q_{1opt}}\right]^2 \cdot \prod_{j=1}^{13} k_j; \\ F_{2opt} = f_2 F; \quad Q_2 = w_2 Q; \quad q_2 = \dfrac{Q_2}{F_{2opt}}; \quad Y_2 = Y_{2\max} \cdot \left[1 - \dfrac{q_2}{q_{2opt}}\right]^2 \cdot \prod_{j=1}^{13} k_j; \\ \dots\dots\dots\dots\dots\dots \\ F_{Nopt} = f_1 F; \quad Q_N = w_N Q; \quad q_N = \dfrac{Q_N}{F_{Nopt}}; \quad Y_N = Y_{N\max} \cdot \left[1 - \dfrac{q_N}{q_{Nopt}}\right]^2 \cdot \prod_{j=1}^{13} k_j \end{cases} \tag{1}$$

is: f_i, w_i - fraction culture area to the total area, and thermal end apology to general minutes limited minutes of heat.

When evaluating the productivity of plants used approximate e m -empirical dependence of the ultimate productivity of the main factors of any and development of plant-based agriculture (Law indispensable for STI and equivalency factors [32, 33]; the law of the optimum, which states that the greatest productivity occurs when all the factors are in optimal range). It is recommended to use a multiplicative form of a productivity of dependence, which allows you to determine the yield of villages s rural culture in a given year based on the actual condition farmland and farming systems, as well as dependent on the STI on soil moisture and changes in the factors and conditions of plant life (in d, thermal, chemical, food and other land modes)

$Y_{N\max}$ - potential crop yield with optimal combinations of all environmental factors, kg / ha. The potential crop yield is determined by the formula (2);

$$Y_{N\max} = \frac{10 \cdot FAR \cdot \eta}{\lambda \cdot \chi \cdot (100 - \nu)} \tag{2}$$

FAR - the amount of photosynthetic active radiation during the growing season MJ / ha;

TABLE 1. The dependence of the total arrival of PAR (billion. KJ / ha) by wide by s mo t Nosta

Areas	Parish PAR
Surkhandarya	17.2-1 8.2
Kashkadarya	16.4-17.1
Bukhara, Navoi	15.6-16.3
Tashkent, Sirdarya, Jizzakh	14.9-15.5
Ferghana, Andijan, Namangan	14.1-14.8
Khorezm	13.8-14.0
Republic of Karakalpakstan	13.4 -13.7

η - coefficient of useful use of the PAR.

By A.A. Nipochorovichu coefficient useful PAR d e divisible into four groups:

1-group - usually observed 0.5-1.5%; 2-group - good - 1.53%; 3-group - record-breaking - 3.5-5.0%; 4-group - theoretically possible 6.0-8.0%

λ - caloric content of a unit of dry organic matter, MJ / t;

TABLE 2. Calorie content of 1 kg of dry biomass of crops, kJ, average.

Culture	Plant organs			
	Whole plant	Main products	By-products	Root system
Tomato	4540	4420	4350	4240
Cucumbers	4500	4620	4330	3960
Bell pepper	4800	4900	4600	4430
Lemon	4700	4800	4400	4180
Strawberry	3900	3900	3900	3700
Roses	5200	5200	5200	4430

χ - *the* ratio of the masses of the main and by-products; - moisture content in agricultural products.

TABLE 3. Values χ, ν, for some crops.

No.	Crops	% Values	V values
1.	Tomato	11.8	94
2.	Cucumbers	10,2	9 5
3.	Bell pepper	14.1	74

Continuation of TABLE 3.

4.	Lemon	8.2	85
5.	Strawberry	13.8	9 4
6.	Roses	12.7	21

K 1 - coefficient taking into account the deviation of the moisture content of the root layer of the soil from the optimal value for a particular crop;

$$K_1 = \sum_{a=1}^{n} \tau_a \beta_a \tag{3}$$

τ_a - the contribution of a – second phase in the formation of crop yields; β_a - Coe p coefficient, which depends on the value of moisture reserves .

$$\beta_a = \left(\frac{W}{W_{opt}}\right)^{\gamma \cdot W_{opt}} \cdot \left(\frac{1-W}{1-W_{opt}}\right)^{\gamma \cdot (1-W_{opt})} \tag{4}$$

W – available moisture reserves;

$$W = \frac{\omega - \beta_a}{m - \beta_a} \tag{5}$$

ω - soil moisture, in fractions of the volume; - OT - wilting point, in the village of Lakh by volume; m - is the porosity.

W_{opt} - optimum moisture reserves

$$W_{opt} = \frac{\omega_{opt} - \beta_a}{m - \beta_a} \tag{6}$$

ω_{opt} - optimal moisture content of the root layer of the soil.

TABLE 4. The parameter values W_{opt} and γ for various agricultural plants.

Culture	Phase Numbers *					On average for the growing season
	1	2	3	4	5	
Tomato	0.55	0.48	0.54	0.43	0.61	0.54
	5.1	5.5	5.6	5.9	5.3	5.6
Cucumbers	0.49	0.54	0.45	-	-	0.51
	5,4	5.7	5.2			5,4
Bell pepper	0.67	0.70	0.65	-	-	0.67
	5.7	5,4	5.9			5.7
Lemon	0.65	0.70	0.65	-	-	0.67
	5.7	4.7	5.7			5.3
Strawberry	0.62	0.64	0.67	0.56	-	0.62
	3.2	5.8	5.6	6.0		5.6

The numerator shows the values W_{opt}, the denominator - γ .

K$_2$ - coefficient taking into account the uniformity of moistening of agricultural lands of various irrigation;

$$K_2 = 0{,}985\sqrt[4]{\left(K_2 \cdot e^{1-K_2}\right)^3} \tag{7}$$

$K_2 = 1 - \frac{h_{\max} - h_{\min}}{h_{кс}}$ - watering efficiency coefficient. Values for various irrigation techniques are adopted according to the irrigation technique used or the technical parameters of the machines used (for example, this indicator is shown in the certificates of sprinkler machines). $h_{\max}$, $h_{\min}$ - maximum and minimum values for the depth of humidification, м; $h_{кс}$ - depth of the root system.

$K_2 = 0{,}88 - 0{,}95$ - with the introduction of a drip system;

$K_2 = 0{,}92 - 0{,}95$ - shielding of irrigation furrow with a plastic film;

$K_2 = 0{,}8 - 0{,}9$ - with laser field planning;

K$_3$ - coefficient taking into account the possibility of changing the yield due to soil alkalization and reducing irrigation quality water depends on the content of adsorbed Na ions, Ca, Mg in soil absorption to m plexus at the end of the billing period, salinity and moisture IU x die soil and groundwater and is determined by the results of the forecast of the water-salt regime of soils;

TABLE 5. Coefficients characterizing the degree of salinization and salinization of soils.

The content of toxic salts,%	Coefficient characterizing the degree of salinization of soils	Value SAR	Coefficient characterizing the degree of salinization of soils
0.1	0.99	2	1,0
0.2	0.78	4	0.8
0.3	0.4	6	0.5
0.4	0.1	8	0.3
-	-	10	0.2

TABLE 6. The condition of crops depending on the degree of salinization of soils.

Soil salinity	The state of agricultural plants
Virtually non-saline	Good growth and development (attacks virtually no harvest Normal s ny)
Lightly salted	Weak inhibition (attacks plants and decrease ur on zhaya 10-20%)
Saline	Average inhibition (decrease of plants and attacks ur about zhaya 20-50%)
Highly saline	Strong inhibition (attacks plants and decrease ur on zhaya 50-80%)
Salt marshes	Single plants survive (almost no crop)

When using saline soils, an alternative approach to the selection of optimal solutions is important. In this regard, the different resistance of agricultural plants should be borne in mind.

K$_4$ - coefficient reflecting disparity actually contains a Nia mineral nutrients in the soil optimal;

The composition and scope of the necessary agrochemical measures include the introduction of organic and mineral fertilizers into the soil. This fact is taken into account when determining land productivity through the coefficient K$_4$, the value of which is determined by the dependence:

$$K_4 = 0,2 + \mu\sqrt{D_{NPK}} \quad (8)$$

μ - coefficient depending on the reaction of the soil solution; - dose of mineral D_{NPK} fertilizers (NPK), kg / ha.

When determining the doses of mineral fertilizers are taken into account: shortage of nutrients; potential crop yields; removal of nitrogen, phosphorus and potassium with the main products and their entry into the soil with crop residues, straw and siderite;

TABLE 7. Coefficient μ depending on the reaction of the soil solution.

Indicators	Soil solution reaction (pH)				
	four	5	6	7	8
Coefficient μ	0.15	0.50	0.90	1.0	0.9
Mineral Fertilizer Efficiency					
The moisture content of the root layer,% PPV	20	40	60	80	100
The effectiveness of NPK, %	35	60	100	80	30
pH	4	5	6	7	8
The effectiveness of NPK, %	75	91	100	100	0

K_5 - coefficient reflecting the deviation of the thermal regime root e inhabited the soil layer from the optimum value;

$$K_5 = 1 - \frac{\delta \cdot T}{T - T_0} \quad (9)$$

where T - - the amount of biologically active daily temperatures Air at ha (over 10 ^{0}C) during the growing period (starting from the optimal sowing date); $\delta \cdot T$ - lost amounts of biologically active temperatures as a result of delay with sowing (or planting) dates;

T_0 - the minimum amount of average daily biologically active temperatures required for plant maturation.

TABLE 8. Minimum amounts of daily average biologically active air temperatures.

Culture	Value
Tomato	3060
Cucumbers	2710
Bell pepper	2890
Lemon	3870
Strawberry	2540
Roses	2080

K_6 - coefficient taking into account the effect of soil salinization on the value of crop yields;

TABLE 9. The values of the coefficient K6 depending on the content of toxic salts in the soil [21].

The salt content, %	0	0.1	0.2	0.3	0.4
The value of the coefficient K_6	1,0	0.95	0.70	0.40	0.10

TABLE 10. Salinity of 0-100 cm saline soil, according to FAO Coefficient of assessment of the effect of the level on crop yield.

Type of cultivation	**ECe, dS/m**					
	2	**4**	**6**	**8**	**12**	**16**
Tomato	100	86	67	48	10	0
Bulgarian pepper	93	65	37	8	0	0
Klupnoy	86	58	30	1	0	0
Perfume	95	76	57	38	0	0
The lemon tree	91	55	20	0	0	0

Note: soil salinity is estimated by the conductivity of saturated soil extract
K_7 - coefficient taking into account the depth of the groundwater level;

TABLE 11. The values of the coefficient K_7 depending on the relative magnitude of the amplitude of fluctuations in the level of groundwater [8].

The relative magnitude of the amplitude of groundwater level fluctuations, m	0	0.2	0.4	0.6
The values of the coefficient K_7	1.0	0.92	0.82	0.7

K_8 - coefficient taking into account the reaction of the soil solution in the year *t of the* calculation period;

TABLE 12. The values of the coefficient K_8 depending on the reaction soil pH.

Soil pH	4.0	4.5	5.0	5.5	6.0	7.0
The values of the coefficient K_8	0.75	0.85	0.91	0.96	1.0	1.0

K_9 - coefficient taking into account the content of heavy metals in the soil in the year *t of the* calculation period;

TABLE 13. K_9 values for various soils and pollution.

Cd, mg / kg	Productivity		Pb, mg / kg	Productivity		Zn, mg / kg	Productivity	
	Sod-podzolic soils	Chernozem soils		Sod-podzolic soils	Chernozem soils		Sod-podzolic soils	Chernozem soils
2.5	1.0	1.0	125	1.0	1.0	125	1.0	1.0
5	0.95	1.0	250	1.0	1.0	250	0.65	1.0
10	0.65	1.0	500	0.95	1.0	500	0.50	1.0
20	0.50	0.90	1000	0.50	1.0	1000	0	0.85
50	0.35	0.75	2000	0.10	0.85	2000	0	0.60
100	0	0.45	-	-	-	-	-	-

To $_{10}$ - correction factor for climatic conditions.

TABLE 14. Value $K_{10.}$

Climatic zones	Ci	C-II	C-I	C-II	Yu-I	Yu-II
K_{10}	0.83	0.92	0.96	1.0	1.04	1.08

The concept of the theoretical and methodological model of the greenhouse farming market is developed, based on the introduction of innovative technologies, taking into account state regulation that influences the main market parameters and includes strategic directions for increasing the effectiveness of greenhouse vegetable cultivation based on product quality differentiation (highly competitive, medium-competitive and low-competitive), aimed at increasing the sustainable development of the market, taking into account its segmentation and consumer preferences [34, 35]. Trends are determined and forecast scenarios for the development of the greenhouse vegetable market are developed (basic, compromise, intensive ones), depending on the level of state support and incentive mechanisms on the basis of an analysis of the actual indices of its capacity, which allow determining the level of self-sufficiency and import substitution, taking into account the cluster-territorial approach, realization of a set of organizational and economic measures that increase the performance efficiency of greenhouse vegetable farming.

CONCLUSIONS

The applied econometric approach accurately reflects the dynamics of the greenhouse cucumber price. Also the approach can be used for preliminary forecasting of the average price for other greenhouse vegetable crops, at least for the nearest calendar period. The calculated correlation coefficient (k = 0.93) between the actual data and the simulated trend, taking into account the seasonal and random components, indicates a sufficiently high degree of adequacy. For a more accurate price forecast for greenhouse vegetables, it is necessary to consider the qualitative composition of costly and other external factors for the theoretical construction of the response function. Modeling the pricing of domestic greenhouse products will make it possible to increase the predictability of the demand for greenhouse vegetables and to achieve certain uniformity in their production and sales, producing a stable profit.

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