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TECHNICAL AND ECONOMIC FEASIBILITY OF THE BLOCK MODULAR COMPLEX *

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TECHNICAL AND ECONOMIC FEASIBILITY OF THE BLOCK MODULAR COMPLEX

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In comparison with the traditional method of vegetable growing in different cultivation systems with glase or plastic protection the modular systems of continuous growing with artifitial light have the following advantages:

1. A daily output of production is guaranteed independently from the environmental conditions.

2. The system allows to save money on the storage of the products and energy consumption, to avoid additional costs related therewith because the products are commercialized directly after their collection from the conveyor.

3. The system permits to cut down the transport expenditures to deliver the products to the market because the BMC may be and should be mounted on a site near the potential consumers (industrial plants, dwelling complexes, hospitals, schools, sanatoriums etc.).

4. The system makes possible to diminish considerably the energy costs especially in the Northen zones, extreme climatic conditions and in the regions of risky cultivation because the energy is saved on the heating of the vegetation rooms (for the heating the sources of illumination of plants are used), on the vapour treatment of the soil to kill the pests (because there is no soil in the BMC), on some technological operations which are necessary in conventional greenhouses but do not exist in the BMC.

6. The labour expenditures per unit of production, depending on the cultivated crop, are 1.5-2 times less and the working conditions are more comfortable.

7. The water consumption decreases (almost 10 times less) because the condensate produced by the microclimate system from the vegetation section air is used almost to 100%.

8. The possibility of infection of the plants with pests is reduced practically to zero, which cuts down the production costs and contributes to its better quality.

9. The use of the BMC as an agricultural shop within an industrial or any other enterprise will allow them to save their own resources, including the energy, because the BMC cousumes the electrical power, mainly, at nights, when the idustrial equipment does not work.

10. The stable agrotechnical conditions in the BMC allow to receive year-round a high quality product with increased content of vitamins and without the substances harmful to the human organism.

11. A considerable reduction of agricultural areas (15 times less) a feature which is very important if the BMC is mounted within a city boundaries where drastic deficit of free areas exists.

If the BMC is used for growing medicinal plants for raw material to the pharmacentical enterprises the latter will hove a guarantee of continuous, year round supply of this raw material and a good competitiveness.

When the BMC is used as a selection center the terms of obtaining new varieties of plants are reduced by 5-10 times.

As it is mentioned in the previous report the BMC is composed of two modules: one for fruit - vegetables growing and another for leaf vegetables and sprouts.

Module for fruit and vegetables growing

The cultivation house is designed to ensure for the plants, far from their natural habitat media such conditions which guarantee their rapid growth. The varieties of vegetables most suitable for groming in hydroponic installations on the protected soil are, generally, of subtropic origin. They differ from the hothouse vegetables in that they do not have dormant stages which could be used to force the plants. All these varieties are sensitive to cold and have equal optimal growth temperatures of 20-25 °C and, in extreme cases, the temperature may fluctuate from 12 °C up to

35 °C. In the given case the system is used to grow tomatoes (the planned output is 150-170 kg/day or 60 tonnes per year) or cucumbers (170-190 kg/day or 65 tonnes per year). The artificial illumination is designed so that this costly factor is optimized.

The light produces a number of qualitative effects on the plants:

- it affects the photosynthesis only in a very limited spectral range;

- along with the formation of biomass the light produces a substancial influence on the construction of the plants: for example, the ultraviolet rays regulate the direction of growth;

- the plant development depends considerably on the photoperiodicity;

- the lighting system is a fairly costly productive factor. A large part of the light energy of the lamps (70-80%) is lost in heat;

- the plants can only partly use the received light; it is either reflected, passes through the leaves (transmission) or is absorbed by them. Each of these values depends on the wavelength. For example, the not lowered leaves reflect in the infrared range about 70% of the rays fallen on them. In the range of visible light, on the contrary, only 6-12% are reflected and the most of all the green light is reflected, i.e. 10-20%; as for the orange and red light spectrum only 3-10% are reflected. The ultraviolet light absoption is 97%. The pellucidity of the leaves depends greatly on their thickness and amounts to 10-40%. On the other hand, the dependence on the wavelength is inversely proportional to the reflection. A large amount of the absorbed light is transformed into heat and is used for the evaporation of the water and a small part is used for the formation of the organic substance. The ultraviolet light is absorbed mainly by the cuticle so that the lower layers receive slightly more than 1-5% of light. In the lower layers chloroplast pigments (chlorophil and carotenoid) absorb about 70% of the s[illegible] light and thus determine the radiation, used for photosynthesis in the form of photosynthetic active radiation (PAR).

It means, that the productive factor - the light - may be also used repeatedly. In this case those fractions of light which are ineffective for the photosynthesis are used to maintain the microclimate in the system. For this purpose 630 lamps of 400 W are mounted in special translucent tubes. The fractions of a percent useless for the photosynthesis are absorbed by the filters and transformed into heat energy. In this way not only the energy is saved but the heat acting on the leaves surface is also reduced and, consequently, the evaporation is lessened.

The table presented below may be a guide to determine the amount of light necessary for the plant growing:

	W/m^2	lx
Initial phase, photoperiodic effects	0,9	100
Stamina of the plants	3	800
Maintaining of the growth	9	2500
Reproduction	18	5000
Production	Over 24	7000

In traditional raising the plants may suffer from water deficit in the soil. Besides the water is used ineffectively bacause its major part is lost by evaporation from the soil. In hydroponics the water lack does not exist because it is contained in the nutrient solution. The same occurs in the case of losses through the evaporation, which may be substantially reduced if the water is storaged in closed tanks. The water losses, are limited in this case by the inevitable "transpiration losses" through the surface of the plants which may be reduced by way of optimization of the illumination of the plants.

The water absorption prevents the withering of the plants. Simultaneously with the photosynthesis large amounts of water are released into the environmental media as a result of transpiration. For the evaporation of such amounts of water, depending on the environmental temperature, different levels of energy consumption are required: 0 °C - 2.5 kJ/g H_2O; 10 - 2.48; 20 - 2.45; 30 °C - 2.43 kJ/g H_2O.

The initial water for the preparation of the nutrient solution must not contain phytotoxic components. The toxic effects on the vegetable plants may be produced by the following amounts of the most common components, in ppm:

	Very sensitive	Sensitive	Mean	Highly
Excess of salts	250	500	750	1000
Chloride	50	100	200	300
Natrium	50	100	150	150
Sulphate	100	200	250	300
Hardness	6	12	20	30
Hardness with calcium carbonate	4	8	15	25

In hydroponic system the resources of nutrient substances for a single plant are much less in comparison with hard substrate. This factor has its advantages and disadvantages. The concentration of nutrient substances in the nutrient solution should be continuously controlled and corrected meanwhile in the soil, under certain known conditions, a single seasonly application of fertilizer is enough. This seemingly difficulty in the technological process is overcome by using the technical means to control and meter automatically and continuously the nutrient solution and its components. This allows to grow the plants which, even is winter, contain small amount of nitrates and are far more rich in mineral substances.

Module for growing green vegetables and sprouts

It is not quite right that the plants perform the metatolism due only to photosynthesis. In many critical phases of growth, as for example, when germinating or forcing the sprouts, the accumulated reserves of the plants are used. These reserves participate in the process of metabolism of the plants as it occurs in animal feeding. Of course, the coefficient of the internal use is much higher then when feeding the animals.

For the production of the sprouts and forcing the plants and vegetables the seeds are used or other accumulative organs which possess a high germinating capacity or strength and have sufficient reserves of starch and albumen.

Numerous experiments conducted in different countries prove that for the human organism the sprouts of different bean crops are suitable for food (soyabeans, mungo, maiz, cereals) as well as the sprouts of different vegetables (radish, salad) and others.

The forcing of leek, chicory, root parsley, rhubarb, plain parsley etc. is well known but limited by the existing technologics.

This problem is solved with the aid of the module for the green vegetables growing and forcing of sprouts. This module with the irrigation, lighting and ventilation systems in comparison with the traditional cultivation in the soil has the following advantages:

- since there is nc soil and no substrate whatsoever there no danger of infection;
- the collection of the crop and its packing are very easy;
- the crop is collected in short terms due to the optimized temperature and air humidity;
- ventilation by the exhaust air from the module of fruit vegetables enriched with oxygen (O_2);
- the whole technological process - growing, irrigation, collection - is mechanized as well as the mass accretion;
- the optimal illumination or its stopping;
- the use cf the CO_2, released by the sprouts, in the vegetable module to stimulate the growth of the plants in it.

The system is designed to grow the leek in one block and the sprouts in another.

The block in which the leek is grown in 3 storeys, has 4 belt conveyors of 9.0x1.60 m. With the distribution of 8 kg of onions on 1 m^2 from 1382 kg of onions used may be received 3802 kg of green onions. Each new loading contains about 250-350 bulbs on 1 m^2 at 22 °C and from them the green onions are forced up to 25 cm high. For the formation of the chlorophil in salad onions the light intensity of 1000 lux is needed. If a half capacity of the system is used year-round the annual output amounts to 76 tonnes.

A similar block with belt conveyor is used to grow the sprouts in the darkness. Suppose that the 5th belt is used for maiz sprouts growing the three storeys are filled with 10 kg of maiz and the sprouts are collected during 5 days. The sweet and rich in vitamins product is served for salads and seasoning. A year-round technological cycle would give about 100 tonnes of maize sprouts per year.

The two following belts (the 6th and 7th) may be used for soya beans sprouts. The amount of 10 kg/m^2 in year-round cycle would yield 250 tonnes. The 8th belt could be used for special products with the annual output of 100 tonnes. It goes without saying that each of 8 belts may be used for growing the sprouts from the seeds of any crop so that different season combinations are possible.

The module designed for growing of leaf vegetables may be successfully used for the production of green fodder from the cereals (barley,oats, rye, wheat) to feed the animals and in comparison with the growing of fodder in the open ground conditions this technology has the following advantages:

1. A fresh green fodder of high quality containing a great deal of vitamins is produced in a guaranteed quantities every day all year round.

2. A very low consumption of water which represents about 1% of the total quantity of water consumed in the traditional cultivation; moreover, the water may be used with increased content of salts (up to 4000 ppm) whereas it is not possible to use for the growing of fodder in conventional conditions.

3. The area, occupied by the module, represents about 0.02% of that which would be necessary for the production of the same quantity of fodder in the open ground.

4. A BMC located directly near a live-stock farms allows to save money on transport and other additional expenditures connected therewith.

5. The green fodder is free of impurities and other matter from the environmental media, from insects and pests. The pure fodder prevents the epidemics of the cattle.

6. The possibility of milk production (up to 40%) and its regulation depending on the market demands by means of the optimal feeding rations with the additions of green fodder. When the green fodder with constant composition parameters is used ration calculations are needless.

7. Due to the optimal fodder rationing the general conditions of the live stock are improved, reproduction capacity and milking period are also increased which are especially important in the calid regions where the climate affects negatively the cattle and its productivity.

8. The high nutritive qualities of the green fodder allow to use a low grade additions, like, for example, straw etc. Thus, a fodder ration of a milking cow of 6000 liters during the lactation period (20 lit/day) consists of the following components: 30 kg of green fodder + 5 kg of concentrate + 6 kg of straw.

Besides the abovementioned advantages there are also a series of others which are impossible in conventional cultivation of agricultural crops.

Economic evaluation

The design of a BMC shall include the investments necessary for its building. The total balance (costs - profits) should be computed on the basis of the productivity values and their comparison with the output values expressed in the same terms. Usually, only those values are taken into account which may be evaluated in pecuniar terms omitting such factors as environmental media, light, rain etc.

If a conventional greenhouse is designed these factors are strictly evaluated and this means increased investments and operating costs.

Due to a completely independent functioning of a BMC it has a considerably greater coefficient of performance.

An example of costs and profits calculations for a BMC is given below.

Investments

	Roubles, currency
Equipment cost	2 500 000
Structure	200 000
Mounting	50 000
Miscellaneons	50 000
Total	2 800 000
Buildings quota	700 000
Machinery & equipment	2 100 000

Production, raw material, yield

Module for fruit-vegetables growing.
Output 150-170 kg of cucumbers or tomatoes.
Annual yield: 54 tonnes.

Unit for growing of green vegetables and sprouts.
Products: leek, soya, lentil, maiz.

Means used.
a - length of belt
b - width of belt
c - number of belts
d - mass accretion of raw material
e - loading periods in a year
a x b x c x d x e = raw material weight/year.

Onions	8 kg/m^2, 20 vegetation periods, 9x1.6x12x8x20 = 27 648 kg/year
Soys	10 kg/m^2, 90 vegetation periods, 9x1.6x6x10x90 = 77 760 kg/year
Lentils	10 kg/m^2, 60 vegetation periods, 9x1.6x6x10x60 = 51 840 kg/year
Maiz	10 kg/m^2, 72 vegetation periods, 9x1.6x6x10x72 = 62 208 kg/year

Yields.

a - length of belt

b - width of belt

c - number of belts

d - weight of the sprouts yield

e - filling periods/year

a x b x c x d x e = yield weight/year

Leek	22 kg/m^2, 20 filling periods, 9x1.6x12x22x20 = 76 032 kg/year
Soya	30 kg/m^2, 90 filling periods, 9x1.6x6x30x90 = 233 280 kg/year
Lentils	25 kg/m^2, 60 filling periods, 9x1.6x6x25x60 = 129 600 kg/year
Maiz	30 kg/m^2, 72 filling periods, 9x1.6x6x30x72 = 186 624 kg/year

Expenditures

Number of fillings x cost

Cucumbers (Planting material)		2 000 roubles carrency
Leek	27648x0.55 =	15 206 r.
Soya	77760x0.45 =	34 992 r.
Lentils	51840x0.43 =	23 328 r.
Maiz	62208x0.30 =	18 662 r.
Total		94 188 r.
Total to be considered		95 000 r.

Profits

Yield amount x yield index

Cucumbers	54000x3.0 =	162 000 r.
Leek	76032x1.1 =	83 635 r.
Soya	233280x1.3 =	303 264 r.
Lentils	129600x1.0 =	129 600 r.
Maiz	186624x0.8 =	149 299 r.
Total, profits		827 798 r.
Total, to be considered		820 000 r.

Expenditures on the means of production

Power	3.4 mln kW/yr x 0.02 rouble =	68 000 r.
Chemicals		8 000 r.
Water	35000 m^3 x 0.1 rouble =	3 500 r.
Spares		40 000 r.
Materials used		8 000 r.
Other		50 000 r.
Total		132 500 r.

Labour, technical maintenance, transport

Expenditures on labour	2200 r. x 14 months =	29 400 r.
Transport		12 000 r.
Means of production		3 000 r.
Miscellaneous		5 000 r.
Total		49 400 r.

Basic data for economic calcutations

Investments in buidlings	700 000 r. (15 years of service life)
Machines	2 100 000 r. (8 years of service life)
Profits	820 000 r.
Labour expenditures	49 400 r. (3%)
Material expenditures	227 500 r. (3%)
Percent rate on capital	7.25%/yr
Means of production	3.5%/yr

Profitability calculations of two versions:

version 1 - counting the above indexes;

version 2 - counting the above indexes and profits decrease of 25%.

Conclusions

The calculations show that in both versions 1 and 2 (yields decreased down to 75%) the technology is profitable.

A joint venture in this field is a profitable enterprise in extheme conditions and arid zones. The technology allows to successfully use the excess of production of natural zones of growing for guaranteed and dosed provision with vitamins of the people living and working in such zones. This will allow to make the life of this people independent from the outside factors.