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PLANT-GROWING TECHNOLOGIES IN BLOCK-MODULE COMPLEX *

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PLANT-GROWING TECHNOLOGIES IN BLOCK-MODULE COMPLEX

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The science of plant nutrition has started its neccessful progress only after the introduction of J.-B. Bussengo's method of "vegetation experiments" and also the methods of soil modelling with its substitution by artificial substrates (pearlite, vermiculite, pourous clay filler, gravel, etc.) or water culture with nutrient application. Liebich, Knopp, Gelrigel, Timiryasev, Pryanishnikov and many other scientists laid foundations for creating a comprehensive theory of plant mineral nutrition.

The theory has underlied the determination of plant requirements in the block elements and the ways to specify the plant nutrition regime, the production of different kinds of fertilizers (including those completely dissoluble and, on the contrary, the ones with a restrained capacity for dissolution and slow nutrient release), the substantiation of dozes and forms of fertilizers being introduced with regard to the plant ontogenesis phases, the culture type, the natural productivity of soils, their absorbtion capacity and acidity, and the method of supply to the plants (root or extraroot nutrition). Thus, the agriculturist has learned to control the fertility of soils and accordingly, the amount of crop yiels. His dependence on the land has considerably decreased.

It goes without saying, the positive influence upon the amount of crop yield has been exercised by a more qualitative soil tilling with specialized machinery, extension of artificially irrigated areas, employment of effective means against weeds, pests and pathogenic agents affecting crops. At the same time recent measures have been taken to reduce the possible crop losses.

High crop yields have also become possible due to the creation of productive disease resistant varieties and hybrids with valuable genetic characteristics.

The further increase of pruductivity, however, will be attained through further straining of creative thought and energy of farmers.

It is known that through achievements of selectionists, development of agrotechnical methods of plant raising and application of mineral fertilizers the productivity grows up to a certain level, which can be overcome only by means of:

- artificial stimulation. Of special importance here is the use of preparations of wide physiological action, obtained from natural compounds of high physiological activity, that influence on many sides of plant vitability, increase general non-specific resistance of plants against environmental extreme effects, accelerate seed sprouting and their germination power, enlarge daily increment of green mass, resulting, on the whole, in the increase of yield and its quality improvement. These preparations are inexpensive (as compared with the physical stimulation methods and synthetic chemical stimulants), harmless and do not upset the environment ecological balance;
- the application of tissue-and-cell cultures method to produce virusfree forms of plants and the plants with the improved quality of final product;
- the creation for plants of the whole complex of favourable conditions of life in the houses with artificial climate. It implies both the extension of traditional hothouse areas and the introduction into the agricultural process of vegetation structures of a new type, designated for the year-round conveyor plant cultivation under the artificial light conditions.

Only in such protected environment plants are provided with a complete liberation from "the power of land", i.e. unfarvurable soil, climatic, temperature and light conditions. There are no weeds, pests and pathogenic agents affecting crops there (on condition that prophilactic measures of plant protection are strictly carried out). The possibitily to regulate all enviromental factors to a large extent enable to set optimal parameters for every definite culture, thus determining the acceleration of plant growth and development, and also the understanding of their genetic structural potentialities.

Here are a few examples. In the USSR at the year-round light installations in hydroponic conditions the determinant tomato varieties (Pushkinsky, Ottawa, Starfire) ensure a crop of 25-35 kg/m^2 for 75-80 day. It means that up to 140 kg of ready for use product can be obtained from this area per year. Cucumbers under these intensive light conditions yield from 60 to 72 kg/m^2 and with 3 crop rotations give 200 kg/m^2 (Arisa and Lada hybrids). Salad radish, with edible leaves and roots, yields 21 crop per year, equivalent to 150 kg/m^2.

The hothouse Dutch variety of the Forster grapes, small one-bud cuttings has formed 2-3 ripe clusters for a period of 4 months, their total weight being 1 kg per average plant.

This list of examples might be continued, but what has been said is quite sufficient to have an idea of the possible productivity of plants with continuous cropping them under the artificial conditions.

Nowadays it is by no means easy to imagine the future of selection outside of such structures, since the growth and development speeding up with the possibility to cultivate them year round allow to shorten the selection process by 5-7 times.

The genetic and selection work on tree seedlings is also speeded up.

Under such conditions wide prospects come to light for cultivating medicinal plants with a view to continuously produce the basic material for pharmaceutical industry.

Plant cultivation closed systems constitute a new step in search of economical way of producing horticulture green cuttings (grapes, sea buckthorn, etc.) in combination with the application of natural stimulants and method of long term storage (before the transplantation into the open soil) of ready planting material.

Enviromental factors have a complex effect upon plants. Therefore a quantitative change of one of them causes the inevitable alternation of the others. In the blockmodule complex, in particular in the circulation system of the main module the light flux power is determined by the desion (a constant number of the light sources) and their intensity. This means that the irradiation intensity remains at the same level in the course of the whole ontogenese of cultures under cultivation. On the basis of the irradiation intensity value, a relationship of such environmental parameters as the CO_2 concentration in the module air, the photoperiod (dayitme and nighttime phase duration) and also the temperature regime should be selected.

The CO_2 concentration increase in the air of the closed systems, as compared with natural conditions, increases the photosynthesis rate, but to a certain limit, and depends directly on the plant irradiation level. Thus, the CO_2 concentration in the air may both restrain and inhibit the photosynthesis. Under the main module conditions the CO_2 must be supplied during the daytime, distributed evenly and maintained in the range of 0,1% + 0,15%. It is practically the optimal CO_2 concentration at the given plant irradiation level (50-75 wt/m^2 in the sphere of physically active radiation - PAR). Besides, it does not cause any inconvenience for the personnel during the first working hours (with the approach of nighttime phase).

The radiation spectrum composition has a reliable influence on the plant physiological processes at different stages of their development (varying with plants of long and short day), but solely in case of a low radiation intensity and a short light period. Provided the light flux intensity is more than 50 wt/m^2 PAR the plant spectrum requirements are levelled as in case of the daily light doze increase. This commonly known statements has been verified by our experiments when sodium lamps (of ДНаТ-400 and SON-H-1 type) and metalhalogen vapour lamps (of the ДРИ-400 and Tungsram-350 type) have been used.

In the main module, when the light period duration was 16-17 hours, the plants underwent the main phenophases for the terms typical of the conditions of high light flux power and day lengths of 14 hours. Thus, the radiation spectrum composition of selected radiation sources does not show any visible negative effect on the plants.

As for such an important factor as photoperiodism (an actinometric factor), its influence usually determines both the terms of separate phenophases and the transition to the reproductive development, and the very possibility of their realization.

It has been observed that under natural conditions the earth actinometric regimes inhibit the advancement of many plant species to other regions from the areas of their successful vegetation. This very factor is also connected with both the radiation intensity and the "dark" processes, and, consequently, with the temperature regime in the day and night time. Certain relations between the lighting intensity and the daytime period duration are of particular singificance. The lower is the illumination intensity, the longer must be the day time, and the shorter is the day, the more important is to increase the lighting intensity. From the standpoint of light and energy consumption by the majority of main vegetables (tomatoes, cucumbers, pepper), the best conditions are considered to be the combination of a 14-hour day and the illumination intensity up to 150 wt/m^2 PAR.

The block-module system under consideration possesses all the advantages of closed cultivation structures. Besides, it has some distinctive biothechnical peculiarities of its own. Since the main module in this system is a tower-type structure with a minimum base area and a three-dimension vegetation space equipped with a spatial light net during the light phase, the plants are continuously moving up and down between the light sources. This makes it possible, on one hand, to rationally use the whole volume of cultivation structure, and, on the other, to provide plants with the conditions for involoing the whole assimilation appartus of plant vegetation mass into the photosynthetic activity. This enables the plants to utilize fully the radiant energy, if the cenosis optical structure and the architectonics of each plant are rationally formed. In the main module conveyor system the mean spherical level of the plant radiation intensity is about 50-75 wt/m^2 in the sphere of the physiologically active radiation. But,due to the volumetric irradiation,the plants of cucumber are well developing under these light conditions, forming short internodular segments and brightly coloured green leaves with a normal relationship of chlorophyl a and b, equal to 4, that points that the illumination is sufficient. In the module seedling section the irradiation level of young plants is 100 wt/m^2, which guarantees the development of strong and healthy sprouts.

As it is mentioned above, under the main module conditions where the illumination intensity is twice less (50-75 wt/m^2 PAR), the daytime period has been prolonged up to 17 hours.

The further day prolongation does not ensure any considerable increase of dry substance accumulation. Provided that the light intensity is relatively low,it is necessary to maintain in the module the air temperature not less than 25 °C round-the-clock. During the nightteme period its reduction is allowed not more than 5 °C. Under the intensive photoculture conditions with the high illumination intensity and air temperature in the range of 25 °C + 35 °C the overheat of plants is observed,causing their productivity decrease. In this case it is necessary to have either effective ventillation or to lower the temperature. However, the night temperature fall by 10 °C inhibits distinctly the growth processes, delays the reproductive development and considerably cuts down yields. During the experiments on tomato raising with the daytime length of 10, 12, 14, 16, 18 and 20 hours the temperature of 30 °C has been maintained round-the-clock in one test series, and in the other at night time the air temperature fell to 20 °C. In all day duration variants the dry substance accumulation and development rates have been higher at constant temperature than during thermoperiodism. This effect is apparently explained by the processes going on intensively in darkness at a high night temperature.

The nutrient of the following composition has been chosen for mineral nutrition of plants in the main module.

Table 1

The Nutrient composition for 1500 ppm

Macroelements	g/1000 l	N	P	K	Ca	Mg	S
	682	81,2			115,3		
	273	38,2		106,5			
	273		62,2	77			
	273					27	35,5
Microelements	**g/1000 l**	**Fe**	**Mn**	**Zn**	**Cu**	**B**	**Mo**
	68,20	4,1					
	4,20		1,02				
	0,30			0,07			
	0,20				0,07		
	1,16					0,20	
	0,25						0,14
Acid	10% H_3PO_4 or HNO_3						

Requirements for Chemicals and Their Purity:

calcium nitrate .... 15,5% N
potassium nitrate .... 13,7% N; 38,6% K
potassium phosphate .... 54% K_2O; 41% P_2O_5
magnesium sulphate .... 10,6% Mg
Fe-trilon .... 9% Fe
manganese sulphate .... 24,6% Mn

zink sulphate	36% Zn
copper sulphate..................	
boric acid	15% B
ammonium molybdate	39,7% Mo

Annual chemical consumption for Block Module Complex, kg:

calcium nitrate $Ca(NO_3)$	850-1200
potassium nitrate KNO_3	350-500
potassium phosphate K_2PO_3	450-700
magnesium sulphate $MgSO_4$	350-525
Fe-trilon (9%)	60-90
manganese sulphate $MnSO_4$	6-9
zink sulphate $ZnSO_4$	0,3-0,5
copper sulphate $CuSO_4$	0,25-0,40
boric acid H_3BO_3	2,5-4,0
ammonium molibdate $(NH_4)_6(Mo)_7O_{24}\ 4H_2O$	0,5-0,8
	$\sum$ 2069,55-2948,70 kg

In every technological section a substrate of different concentration has been employed for tomato raising: 1) in the nursery - 0,1%, 2) on the induction conveyor - 0,15%, 3) on the production conveyor - 0,2%.

The nutrient substrate adjustment is carried out automatically in line with the pH value and the nutrient electric conductivity indices by an impulse feeding of a required doze of concentrated salt solutions from two tanks A and B. Periodically (once in two weeks) the chemical analysis of the nutrient solution is carried out and on the grounds of its results the adjustment of the latter is done. To prevent the accumulation of organic agents - metabolites (more than 15 mg/l^{-1} of the CO_2 equivalent content) in the nutrient, solution, it should be changed for the fresh one.

In the production section of the main module the nutrient should be renewed once in 7-10 days, in the induction one - twice a month, in the nursery-every 10 days (since there is no automatic adjuster in the nutrient tank).

To prepare high yields it is expedient to provide the plant roots with the biogenic elements, water and air. This requirement is observed by the periodical flooding of the root systems in the cubes. A sufficient aeration of the root system takes place on the inclined vegetation trays of the induction section where the nutrient solution is renewed every ten minutes by feeding it to one end of the tray and draining it from the other.

In the circulation system it is important to thermostat the trays to avoid solution heating by the light sources.

The profitability of the production process and the cheapening of final produce in the blockmodule system undoubtedly depends upon the plant productivity attained, which in its turn is determined by the degree of elaborating particular technologies and finding correct relationship of environmental parameters.

The Main Hydroponics Module is intended to grow photocultures on the vertical conveyor.

Let's consider in detail the technology of growing the cucumber culture, most common on the protected ground, high-yielding and sufficiently shade-enduring.

Cucumber cultivation conditions on the main hydroponics module:

Photoperiod	
daytime phase	17 hours
highttime phase	7 hours
Light intensity	
in the nursery	up to 25000 lx
on the circulation system	up to 16000 lx
Air temperature	
daytime phase	26±2 °C
highttime phase	20±2 °C
Air humidity	
daytime phase	70%
highttime phase	85%
CO_2 concentration	1500 ppm

(CO_2 is fed during the daytime phase)	(0,15%)
Nutrient solution pH	6,0-6,2
Nutrient concentration	1500 ppm (0,15%)

The seeds, undergone the thermal processing should be wetted in Petri dishes and placed into the thermostat at the temperature of 26 °C and humidity of 98%. In 24 hours germinated seeds should be planted in the cubes of Grodan substrate and are again placed into a constant temperature cabinet for a day. Then blocks with sprouts are transferred onto the perforated metallic trays at the beginning of the manual conveyor. In a 2-day time the blocks are cut and arranged in a staggered order to provide the most favourable illumination conditions. Every day the perforated metallic trays are shifted manually along the conveyor length. After 14 days the cucumber seedlings in a 3-leaves phase are transferred onto the vegetation trays of the auxiliary induction conveyor where they are arranged in 2 rows at an interval of 47 cm.

At the age of 25 days (the plants having 8-10 genuine leaves) the trays are shifted from the induction conveyor onto the main conveyor. The plants should be fastened to the trellis which is at the height of 80 sm with a gradient of 45°, enabling a better light consumption by the plant leaf surface.

The plant stem reaching the trellis should be twisted around it, lowered down and pinched at the level of the 18-20th leaf; the stem length is of 1,2-1,5 m.

The plants should be under a daily control which comprises the lateral shoot and tendril pinching out, twisting the stems that are getting longer, training the plants and rationing the fruits; on the lateral shoots it is recommended to leave 1-2 cucumbers.

When the cucumber continuous growing technology in the main hydroponics module was being elaborated the following tasks were set forth:

- to determine the best hybrid out of soviet and foreign varieties under given conditions of raising;

- to determine the optimal cenosis structure for top yield output from the cultivation room;

- to define the optimal time spent by plants on the conveyor;

- to find out the influence of raising conditions upon the growth, development and biochemical composition of cucumber fruits.

Particular cucumber hybrids for photoculture have not been proposed by the selectionists of this country; therefore the cucumber parthenocarpic forms for protected ground have been tested. Long varieties of cucumber have been tested (Moskovsky teplichny, Birjusa, Aelita, Farbio) as well as short-fruit (Stella, Lada, Zolotoy petushok) parthenocarpic forms of cucumber.

The results presented in Table 2 show that the choice of hybrid is of considerable importance for getting the maximum output per unit of vegetation area.

When raising cucumber during a 60-day period the Aelita, Stella, Moskovsky teplichny, Farbio, Lada, Ariess varieties have proven to be most high-yielding; the Birjusa and Zolotoy petushok varieties - less productive. At a longer growing period the Zolotoy petushok hybrid has proven to be the best. This hydrid has an attractive exterior appearence and good flavour, distinguishing it favourably among other parthenocarpic varieties.

Table 2

Cucumber yield (kg/m^2)

Hydrid	60 days		90 days		120 days		160 days	
	kg	pcs	kg	pcs	kg	pcs	kg	pcs
Stella	11,5	65	24,0	142	-	-	-	-
Moscovsky teplichny	11,6	64	24,5	125	31,0	159	38,4	203
Aelita	25,0	69	-	-	-	-	-	-
Birjusa	8,5	49	-	-	-	-	-	-
Lada	11,0	75	-	-	-	-	-	-
Ariess	11,0	58	23,0	114	33,0	185	41,1	218
Zolotoy petushok	8,5	54	20,0	125	33,5	190	46,5	238
Farbio	12,5	56	-	-	-	-	-	-

During the formation of cenosis and a higher yield output per unit of the cultivation volume the density of planting is of special significance.

Table 3

Planting density effect on cucumber yield
(vegetation period of 120 days)

Number of plants on a tray	g/plant	kg/tray
20	1395	27,9
24	1295	31,1
28	1030	28,8
30	980	29,4

Table 3 shows cucumber yield data of the Moskovsky teplichny hydrid being r.ised from a seed during a period of 120 days. Individual productivity of plants amounts to 1,4 kg and increases with the reduction of a number of plants on a tray. The total cucumber yield per m^2 decreases both with the planting density increase and the reduction of plant number on the tray. The optimal planting density under given raising conditions has proven to be that of 24 plants per tray with the plant stem length of 1,2-1,5 m.

The largest yield gain of cucumber grown in the module structure occurs on the 90th day and amounts to 6 kg/m^2 for a 10-day period. Then follows a slow recession in yield gains, however, it amounts to 3-4 kg/m^2.

The optimal vegetation term for cucumber plants have proven to be the term of 160 days since the day of sowing, and their further stay on the conveyor leads to the increase of costs.

When raising plants under regulated conditions, of considerable importance is the production of early produce by means of the optimization of growing conditions. Table 4 presents the terms of cucumber phenophases occurence under different conditions of raising. It has been observed during the vegetation period, that the plants grown in the module differ considerably from those raised in the traditional hothouses. When the intensive cucumber photoculture is employed, the seedling development phases proceed twice as fast as in the traditional hothouses, the interncdular interval being 5-10 cm. Mainly the female flowers are formed having a positive effect upon the yield amount at early produce output. When growing plants in the closed system under artificial climate and lighting conditions, of particuler significance is to produce high quality crop.

Table 4

Terms of cucumber plant phenophases

Development phases	Hothouse	Module
of the 2-d leaf	20	12
of the 3-4th	25	15
of the 7-8th	-	23
of the 9-10th	-	27
the starting point of blossoming	55	35
the starting point of fruiting	90	50

Table 5 shows qualitative data of fruits produced in the hydroponic module. The fruits are characterized by high qualitative indices and do not differ from the parthenocarpic cucumber fruits raised in the traditional glasshouses. It should be mentioned that the nitrate content in the cucumbers is below the permissible concentration which is of particular importance nowadays.

Table 5

Cucumber fruit biochemical content

Hybrids	Dry substance, %	Ascorbic acid, mg/%	Sugars, %	Acidity, %	Nitrates kg/kg of raw weight
Stella	2,94	6,88	1,34	0,11	105
Moscovsky teplichny	3,98	5,40	1,46	0,13	120

The experience of operating the hydroponic module system shows that:

- the given conveyor unit may ensure the year-round procedure of the vegetable production;

- the research carried out on the parthenocarpic cucumber hybrids of Stells, Aelita, Moskovsky teplichny varieties most common in hothouse vegetable raising, has shown that fruit yield is practically identical and amount to about 12 kg/m^2 on the 60th day, and about 24 kg on the 90th day. A longterm culture of up to 160 days the Zolotoy petushok variety has proven to be the promising hybrid, its yield amounting to 47 kg/m^2;

- the cucumber cenosis structure with the planting density of 24 plants per vegetation tray and a stem length of 1,2-1,5 metres, ensures the top yield cutupt from the given cultivation structure volume;

- the produce grown under artificial climate and illumination condition has good qualitative indexes.

Tomatoes. The growing conditions of tomato culture in the main hydroponic module, basically, coincide with those of cucumber culture raising, pH of nutrient solution amounting to 5,8, concentration - up to 2200 ppm.

Tomato-raising technology has the following features:

- seed sprouting, sown in the blocks of Grodan substrate in darkness, under the constant temperature cabinet conditions (26 °C) - for the period of 3 days;

- raising of non-pricked off seedlings under the light in the seedling cabinet from the 4th to the 7th day;

- growing and pricking out in the seedling cabinet from the 8th to 21th day;

- seedling planting on to the trays and raising on the intermediate (induction) conveyor from the 22d to 45th day;

- shifting the trays with plants onto the main production conveyor and raising to the plant shooting beginning with the 46th day.

Every plant on the production conveyor should be fasten to an espalier. The lateral shoot pinching off is regularly carried, out not to allow their growth for more than 8 cm.

The blossiming starts on approximately, the 45th day, since this moment, the artificial pollination by special devices has to be necessarily done twice a week. The artificial pollination increases yield productivity by not less than 10% and improves fruit quality. Yield productivity is more than 60 kg/m^2 of the vegetation area per year.

<u>Pepper</u>. The pepper growing technology does not differ much from that of the tomato raising. The optimal temperature of seedling growing is 24-27 °C. Sprouting begins in 6-7 days. Seedling pricking off should be carried out in 12-14 day. The optimal temperature on the production conveyor is 22-25 °C. The plants are fastened to espaliers with a twine. When training plants the first 3-4 and then 2 sprouts are left. It is very important to gradually remove the lower leaves, to artificially pollinate and to remove the tops 40 days before the final harvesting. Crop yield productivity amounts to 30-40 kg/m^2 of the vegetation area per year.

<u>Salad</u>. Growing conditions: the temperature is 18-22 °C during the daytime phase, 10-12 °C during the nighttime phase. When head is formed (head salad), the nighttime temperature should be up to 8 °C, on the eve of harsesting it is up 4-6 °C, and during the daytime phase - up to 14 °C. Relative air humidity is 70-80%. Such temperature-humidity regime stipulates the formation of more solid heads. The vegetation term is 35-45 days, crop yield productivity being up to 6 kg/m^2 for a vegitation period.

<u>Medicinal plants</u>. Aloe arborescens, a perennial evergreen of lyly family, is a valuable basic material for medicine. Different preparations, made of raw starting material (leaves) and lateral shoots of aloe, are being used.

Cultivation conditions:

air temperature	
daytime phase	20-30 °C
nighttime phase	10-15 °C
relative air humidity	42-92%
light	4000-19000 lux
daytime phase duration	16 hos
nutrient pH	6,0-6,5
nutrient concentration	800-1400 ppm

2-3 days after final harvesting the cutting off of tops for taking root should be carried out. The tops are cut off on the 6-7th leaf level or the lateral sprouts of 3-5 cm long are employed.

The grafts are left for a day or two on the lower storey of the seedling cabinet until the callus is formed. Then the aloe grafts are placed in the blocks of Grodan at the depth of 3 cm and are left for 25-30 days in the seedling cabinet for strengthening. Standard sprout is the seedling of 8-12 cm long with a well-developed rootsystem. After the aloe grafts are implanted they are transferred onto the conveyor. The planting density must be in the range of 40 pcs/m^2.

During the vegetation period sick, half-grown and damaged leaves should be removed.

Harvesting is carried out periodically, removing in succession, first of all, the lower leaves, part of which become dry on the tips due to complete ripening. Standard leaf length must be not less than 15 cm. Besides leaves, the lateral sprouts are also collected from the plants of aloe.

Aloe yield productivity is of 2,5 kg/m^2 per year.

A number of other medicinal plants besides aloe may be cultivated under the given conditions.

In the main hydroponic module experiments on raising, the following cultures have also been carried out: watermelon, melon, zuchini, leaf mustard, leaf parsley, dill.

The test results show the possibility of cultivating practically all vegetable cultures under the given artificial conditions.

Auxiliary cultivation block

Auxiliary block of the cultivation structures serves for raising plants that do not require intensive illumination. The block comprises 2 or more vegetation sections where units are located. Vegetation units of the block are made in the shape of multi-storeyed racks intended for growing low-stem plants.

A list of cultures which may be forced successfully on the rack vegetation units and their technological particularities are given below.

Spring onions. To raise spring onions, the thoroughly sorted bulbs of 2-4 cm diameter are used. During the autumn-winter period when the majotily of onion varieties is in a state of a rest, to awaken onions it is effective to cut off the bulb tops or to prick the bulbs 2-3 times on the neck. With this purpose it is possible to wet the bulbs in warm water (35-38 °C) during 12 hours and at the temperature of 25-30 °C - for 24-48 hours. The increase of spring onion yield productivity by 20-25% may be attained when moistening the bulbs in 0,01-0,1% copper vitriol and potassium permanganate solutions before planting.

Planting material is transplanted on the racks by a bridge method; the vegetation term is 25-30 days.

During the first two weeks of vegetation the light is not required, for the next two weeks the lighting intensity must be 500-1000 lux; during the daytime phase the air temperature being 16-23 °C, during the mighttime phase - 14-19 °C; relative humidity - 70-85%.

During the first halftime of vegetation process the feeding by ammonium nitrate of urea of 20-40 g per 10 l of water is effective. The root layer humidity must be close to the general field moisture content. Irrigation should be stopped 2-3 days before harvesting.

Productivity (in % of planting material weight) amounts to 200-220%.

Seedling grafting. A great number of horticulture crops reproduce themselves by grafting: cherries, plums, apples, pears, currants, sea buckthorn, grapes, decorative plants, etc.

There exist 2 ways of grafting - reproduction by green cuttings and arboreous ones. Pearlite or Grodan are used as substrates. The green cutting reproduction occurs at a temperature of not higher than 26 °C and air humidity of 90-95%. Preference should be given to the fine dispersion water spraying with a view to cantinually moisten the leaf surface of cuttings; the grafting time period - 15-40 days depending on the culture type.

The arboreous cutting reproduction method (mainly of grapes) may be realized without substrate, the temperature being not more than 26 °C, humidity - of 80-85%. The grafting time period is 7-20 days, according to the season and the type of culture.

Green fodder for feeding the livestock. The seeds of cultures, presented in Table 6 are used as planting material.

Table 6

Culture	Sowing rate, kg/m^2
Barley	4,6
Rye	4,0
Oats	4,2
Wheat	4,0
Maize	5,0
Soy-beans	5,0
Peavine	5,0
Peas	5,0
Spring vetch, etc.	5,0

Seeds with 90-92% germination capacity should be used free from impurities. The disinfection by the bactericidal lamps of PRK-2 type should be carried out for 3-5 minutes. The prepared sowing material thus prepared is loaded into a special tank,where it should be wetted for a period of 2 up to 24 hours,depending on the culture type. After wet-ting, the planting material should be loaded onto the rack germinator and levelled out in a thin layer (5-15 mm). Germinating is going on up to 8 days (depending on a culture).

Sprouting and further raising is realized with the illumination intensity of 800-1000 lux, in the darkness - for 3-4 days, the optimal temperature being 21-23 °C (for maize - 25-27 °C) and air humidity - 80-85%.

Periodicity and irrigation time are particular for every culture. Nutrient substrate feeding should not be done more frequently than-twice a day. The green fodder looks like "a carpet" of the interwound rootlayer and germinated seeds. The thickness of carpet is of 4-5 cm, the height of green cover - 20-25 cm. The green fodder yield productivity amounts to 20-50 kg/m^2.

Green sprouts. Green sprouts of various cultures have recently become popular in human nourishment. According to the medical data they are rich in mineral salts, enzymes and vitamins and possess biological activity.

The sprouts of the following cultures have become most widely spread:

Trigonellf (flavoured seasoning). It contains protein, aminoacids. The seeds are wetted in water for 5 hours at the temperature of 18 °C, placed on a rack in a layer of 10 mm thick; irrigation is realized for 2 hours a day; vegetation term being 7-8 days. Harvesting should be done when the sprout length is equal to that of a seed.

Black Radish. It is soaked during 4 hours at the temperature of 21 °C; irrigation should be done for 2 hours a day; harvesting must be carried out in 2 days, sprout length being 3 mm. These sprouts are rich in A, C, B, P, P vitamins.

Millet. Its soaking delays not less than 8 hours at the temperature of 21 °C, irrigation must be done daily for 2 hours. Harvesting is carried out in 8 days, sprout length being 2 mm. The sprouts abound in protein, aminoacids, B_1, B_2 vitamins, mineral salts.

Sezame. Soaking should be done for 4-6 hours; daily irrigation for 2 hours; harvesting in 2 days; sprout length being equal to that of seeds. Sprouts are rich in protein, aminoacids, moneral salts and vitamins.

Lucerne. It must be soaked for 4-6 hours at the temperature of 21 °C and irrigated for 2 hours daily; harvesting takes place in 5 days; illumination should be only for a day (the 5th). Sprouts abound in protein, aminoacids, microelements, B, C, D, E, K vitamins.

Mustard. Its soaking goes on for 6 hours at the temperature of 21 °C; irrigation should be done for 2 hours a day. The vegetation period lasts 2-3 days, the sprout length is 3-4 mm or the vegetation period goes on for 6-12 days. Illumination should be done in the interval between the 6th and 12th day. It contains fats, mustard oil glycerides.

Wheat. Its soaking lasts for 8-12 hours at the temperature of 18 °C, irrigation is done for 2 hours a day. Harvesting is in 2 days or in 12 days (after the fat decomposition). Sprouts contain proteins and aminoacids.

Mung bean (green soybeans). It must be soaked for 12 hours at the temperature of 21 °C and irrigated for 3 hours a day, harvested in 5 days with a sprout length of 1-2 cm. Sprouts are rich in choline, vitamins, mineral salts.

Lentil. It should be soaked for 4 hours at the temperature of 21 °C, ittigated for 2 hours a day, harvested with a sprout length of 2 cm.

Chich pea. Its soaking lasts for 12 hours at the temperature of 18 °C; daily irrigation for 2 hours. The vegetation period 4 days, a sprout length is 3-5 mm. Sprouts abound in vitamins, protein, eminoacids.

Hea. It must be soaked for 12 hours at the temperature of 18-21 °C, irrigated for 2 hours a day, harvested in 3 days.

Yellow soybeans. It should be soaked for 2-3 hours at the temperature of 17-18 °C, irrigated for 1-2 hours a day and harvested in 3 days with sprout length of 1 cm.

Cress-salad. Soaking is either not required of carried out for not more than 4 hours at the temperature of 21 °C. Irrigation is done for 2 hours a day. The vegetation period lasts 8 days, a sprout length being 3-4 cm. It is raised with the illumination of 500-1000 lux.

Flax seeds. Soaking must be carried out for 4 hours at the temperature of 21 °C. Irrigation is done for 2 hours a day. Harvesting is in 2 days or in 9 days with a sprout length of 3-4 cm.

Buskwheat is not soaked. The vegetation temperature is 21 °C. It should be irrigated for 3 hours a day and harvested in 2-3 days with a sprout length of 5 mm.

Pumpkin (seeds should be peeled). Soaking lasts 12-16 hours at the temperature of 21 °C; irrigated for 2 hours a day. Harvesting starts in 3 days.

Maize. It must be soaked for 10-15 hours a day, harvested in 5-6 days with a sprout length of 2-3 cm. Sprouts are rich in aminoacids and carbohydrates.

Almond. It should be soaked for 20 hours at the temperature of 21 °C, irrigated for 2 hours a day, harvested in 3-4 days with a sprout length of 5 mm.

The engineering of hydroponics biothecnology equipment is continually being improved in line with the development of scientific technological progress, and the technologies themselves are also being improved; selectionists working out new varieties of different arops which may be used for vegetation under artificial conditions. Scientific thought is persistently elaborating cheap energy sources. The optimization of these aspects will make it possible to solve the problem of providing the population of the earth with food stuffs through the production of secured crop yields in the closed systems of artificial climate by means of hydroponics biothechnology.