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The experience of growing vegetables on multi-level hydroponic systems in polar regions

(Extended abstracts)

1. The development of polar olericulture at high latitudes began with heavy industrial growth in the Russian Far North. The first greenhouses began to appear around 1930-1938 by order of the Chief Directorate of the Northern Sea Route. These primitive greenhouses were stove heated. The cold frames were heated by biological fuels and were constructed from on-hand materials, primarily wood. These structures were used to grow seedlings of white cabbage along with other vegetables during the second crop rotation. Although the productivity of these structures was not high, they provided an opportunity to have fresh vegetables almost year-round and helped save thousands of polar workers from scorbutic diseases.

2. In 1957, all agricultural plots in the Far North were switched to a cost accounting system (Khozraschyot), and by the end of the 1950s, the country began renewing facilities with protected grounds by building greenhouses made from metal and prestressed concrete. Large settlements in the Far North (Murmansk, Vorkuta, Norilsk, Anadyr, and others) began to see modern greenhouses with advanced heating. In 1975, the Far North started to receive shipments of per-fabricated winter greenhouses, making greenhouse olericulture in the region more profitable. In the 1990s, the country went through changes concerning resource ownership, which led to the liquidation of auxiliary developments such as agricultural facilities around industrial sites and oil/gas fields. The residents of

the Far North began to receive fresh vegetables by air. However, only easily transportable vegetables were brought in. It became virtually impossible to receive shipments of table greens vital for a normal diet. Instead, it became necessary to grow table greens in buildings with communal dining facilities, such as kindergartens and schools, where heated floorspace was available. Growing green onions, parsley, and celery in compact, multi-level, hydroponic set-ups has been a success in the Far North (Norilsk), suggesting that such methods may be viable in extreme situations.

3. We used a four-level, and later, an improved five-level, vertical hydroponic system built by the All-Russian Institute for Agricultural Machinery (VISKHOM). The cultivational system "Winter Garden Beds SGUL-30" is a four-level vertical hydroponic system that is 3.2 m in length, 0.7 m in width, and 2.4 m in height. The growing system is mounted to a metal frame, with each level consisting of PVC planters and support beams. The nutrient solution is supplied to the planters using an electric pump. The system is illuminated with low-pressure fluorescent lamps (LB-40) with an irradiance of 120 W/m^2. The nutrient supply and lighting regimes are automated. The improved five-level system (UVR-1200) is equipped with fluorescent lamps (LB-80) that are more powerful.

4. The process of growing green onions consisted of preparing the growth medium, filling the planters, growing the leaves, and harvesting. We used table onions with a diameter of 4-5 cm. We cut the neck of the onion at around 1/4 to 1/5 of the height. The onion bulbs were closely packed side-by-side with a planting density of 18 +/- 0.6 kg/m^2. The onion bulbs were dried for 1-2 days, after which they were installed onto the illuminated levels and growth frames. The lights were turned on at 06:00 and shut off at 18:00. The nutrient solution, developed by V.A. Chesnokov, was dispensed at 08:00 and 17:00. The nutrient solution was replaced twice to account for nutrient losses.

We performed eight rotations to investigate the effects of the lamp color temperature with a maximum

frequency of 440-660 nm for photosynthesis and crop yield. We determined the amount of photosynthesis by using radioactive carbon dioxide. We observed the maximum photosynthetic intensity (4.1 against 2.0 mg CO2 per gram of dried material per hour under the control LB-40 lamps) under the yellow lamps (LB-40) with a maximum irradiance at 590 nm. These observations confirmed the positive effect of the orange-yellow light spectrum on the accumulation of growth mass in leafy vegetable cultures.

The growth of onion leaves under these conditions was 20% higher than under the control and other test conditions, and went up to 12.9 kg/m^2. The forcing treatment period depended on the time of year, and varied between 14-18 days. The average yield was 30.4 kg per m^2 per rotation, or 121.5 kg of green onions from the four levels of the setup per unit, which was 5 times greater than the yield in greenhouses. The productivity of the onion leaves varied between 10.8-12.9 kg. The carotene and ascorbic acid content varied between 1.0-1.6 and 9.2-15.9 mg %, which was within the error bounds of the experiment.

5. Further research showed that multi-level hydroponic systems at high latitudes can be used successfully for forcing chard, celery, and parsley. The yields for these greens, however, were respectively 1.4, 1.5, and 3.0 times less than the yield of the green onions. We studied planting norms, optimal fractions, nutrient delivery cycles, lighting conditions, irrigation norms, microclimatic forcing regimes along with biochemical and quality production characteristics.

The modular hydroponic setup, Latuk, developed for use on the nuclear-powered icebreaker Rossiya, was successfully implemented to grow fresh greens from the Altai onion bulbs. We have experience forcing heads of salad chicory (up to 22 kg/m^2 in planters). The cost of greens grown using multi-level hydroponics is 30% less than that of greenhouses using traditional soils; each ruble invested is recouped with 4.5 rubles of profit.

Conclusions: Forcing greens using multi-level hydroponic systems at high latitudes increases yield from a unit plot by a factor of four or more and reduces the cost of the grown produce by no less than 30%. Highest yields are achieved by growing green onions that are illuminated by yellow-spectrum lighting. It is possible to achieve high yield and high quality produce by growing chard, celery, and parsley using multi-level hydroponic systems in conjunction with technical best practices. We also have successful experience growing greens from bulbs of the Altai onion and heads of salad chicory.