Greenhouse Gardening for the Purpose of Self-Sustaining Ministry in the Former Soviet Union

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Summary

Financial support from overseas for the Christian cause in the former Soviet Union undermines, rather than strengthens, the church when it thwarts the prospect for self-sustaining ministry, and when it stifles indigenous initiative and stewardship. Funds were raised in 2014-15 for a 2016 greenhouse gardening project to demonstrate one approach to lessening dependence upon long term outside contributions. The six sites selected for greenhouses included a church-based rehab center (Ukraine), a group home for orphans in foster care (Ukraine), a ministry center for orphan graduates (Russia), and the rural homes of three low-income, bi-vocational pastors (Ukraine).

Greenhouse sites were chosen that could serve to encourage replication by Eurasian churches and ministries by demonstrating how best to implement greenhouse cultivation on a modest budget. The demonstration greenhouses are relatively affordable (hence small in size); they are durable (hence rust-free galvanized steel framing and long-lasting polycarbonate panel covering); they hold promise of high yield (hence low-cost, gravity-fed drip irrigation); and they are characterized by low overhead (hence passive ventilation to avoid electric fans, and season extension, rather than winter cultivation, to eliminate fueled heating and increased maintenance costs). Requirements for each site included a one-month greenhouse gardening training course (Zaoksky, Russia, March 2016) and detailed record keeping for inputs (labor, soil amendments, fertilizer, herbicides, and insecticides) and yield. Each site director was asked to plant only cucumbers and tomatoes in 2016 to simplify record keeping. Site directors were free in 2017 and are free for subsequent growing seasons to make their own decisions on crop selection, fertilizing, etc.

In particular, the report addresses definitions, greenhouse gardening benefits, the Mittleider Method of cultivation practiced at the Zaoksky farm where training took place, and specifics of greenhouse best practices including size; design; placement; orientation; foundation construction; framing; coverings; growing and transplanting seedlings; soil preparation; ventilation; watering; fertilizing; pruning; controlling weeds, plant diseases, and insects; harvesting; and marketing. The report concludes with an enumeration of practices to be avoided. Appendices provide an historic overview of the issue of dependency (Appendix I), a copy of the Greenhouse Garden Records Journal *(Appendix II), and compilations of individual site and cumulative statistics on multiple categories of labor and yield (Appendices III-VII). The full report in English and in Russian may be downloaded at no charge from the* East-West Church and Ministry Report *website (www.eastwestreport.org) for wider distribution.*

Project Background – The Issue of Dependency

My direct involvement in Christian ministry projects in Eurasia began in the late 1980s. Early on I observed instances of helping that in the long run, hurts. One example was a seminary in the former Soviet Union that received generous Western funding in the millions of dollars with which it was able to build impressive campus facilities. For many years donors from abroad were also underwriting 90 percent of the school's annual operating expenses. Because the seminary property included an apple orchard, a West European Christian foundation proposed the donation of equipment for preparing and bottling fruit juice, the sale of which could help finance the program. Unfortunately, the administration turned down the offer, knowing that students in this heavily subsidized institution preferred to study full-time. Outside support had clearly stifled local initiative and had fostered crippling dependency.

Over time I came to conclude that the debilitating effects of wholesale support from abroad, as illustrated by this overly dependent seminary, were seriously undermining the healthy

development of churches and Christian ministries in the post-Soviet context.[1] After many years of growing concern, I gave a presentation to missionaries in Moscow in May 2006 on "Dependency versus Sustainability in Missions: What Next in the Russian Context?" which proposed three solutions: encouragement of Russian believers' financial stewardship;[2] adoption of bi-vocational ministry to lessen church dependence upon outside funding; and microenterprise development. The response was polite, but no one in the audience seemed to take seriously the long-term negative consequences of churches and Christian ministries heavily subsidized by non-indigenous outside funding. Not satisfied with writing and speaking about the problem, in 2014-15 I began raising funds to launch an experiment in greenhouse cultivation in Ukraine and Russia. (This particular means of promoting self-sustaining ministry first occurred to me in 2011 in Almaty, Kazakhstan, during a visit with a missionary who had the idea of providing small greenhouses to pastors to help wean them from salaries funded from the West.)[3]

After a false start in the Moscow Region in 2015, I was able to secure six greenhouse sites in 2016 through various mission contacts: at a church-based alcohol rehab center (Bucha, Ukraine), at a group home for orphans in foster care (House of James, Selyshche, Ukraine), at a ministry center for youth who have aged out of orphanages (Orphan's Tree, Ivanovo, Russia), and at the homes of three low-income Nazarene, Baptist, and Pentecostal pastors (Kozyatyn, Potiivka, and Min'kivtsi, Ukraine). One Ukraine site director agreed only reluctantly to participate because of a previous unfortunate experience with would-be Western donors who came to take photos of his ministry, who raised money using the photos, but who never provided financial help from the funds raised.[4]

Definitions

Protected or covered agriculture utilizes structures overlaid with transparent plastic or glass to grow vegetables, fruits, and flowers, especially outside the typical growing season.[5] The simplest and least expensive variant is the low tunnel, a knee-to-waist-high structure covered in transparent material over a row crop. Some agriculturalists define a high tunnel as a structure covered in transparent material that is at least stand-up height and that is not heated, whereas a greenhouse is defined as a high tunnel with fueled heat.[6] However, in popular usage and in this report a greenhouse is defined as a high tunnel for growing plants, with or without heat. Another differentiation contrasts a winter greenhouse (requiring fueled heat through the coldest months) with a spring greenhouse (which extends the growing season by means of passive solar heating).

Greenhouse Benefits

While the primary purpose of the 2016 greenhouse project was to demonstrate one approach to overcoming dependence upon overseas funding for ministry in the former Soviet Union, additional benefits became apparent. These include fresh, quality produce for vulnerable foster children, orphan grads, recovering alcoholics, and families of low-income pastors; training in marketable skills for the disadvantaged; and fostering in greenhouse workers a sense of dignity and self-worth that comes from contributing to one's own livelihood.

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[1] Hans Vaxby, "Striving for Congregational Self-Sufficiency in Eurasia: A United Methodist Case Study," *East-West Church and Ministry Report* 19 (Summer 2011): 1-3; Lesslie Newbigen, *Unfinished Agenda, An Updated Autobiography* (Edinburgh: St. Andrew's Press, 1985, 62.

[2] Sergey Chervonenko, "Stewardship in the Church: the Theology and Practice of Tithing, Offerings, and Stewardship in Evangelical Churches of Russia," Asbury Theological Seminary, Doctor of Ministry dissertation, May 2017.

[3] Anonymous, "Kazakh Church Dependence upon Foreign Support and Ways to Overcome It," *East-West Church and Ministry Report* 20 (Fall 2012): 1-5.

[4] Alison Giblett to author, 2 July 2016.

[5] Paul V. Nelson. *Greenhouse Operation and Management* (Reston, VA: Reston Publishing Company/Prentice-Hall, 1978), 27.

[6] Shubin K. Saha. *Protected Agriculture*, Horticulture Department Fact Sheet 7003, University of Kentucky College of Agriculture, Food, and Environment.

While a greenhouse requires a greater investment in time and money than an equal size open-field plot, the advantages of a covered structure more than compensate for the additional costs.[7] When properly worked, greenhouses dramatically improve crop quality and yield.[8] In the cold winter climate of northern Ukraine and most of Russia, heated, all-season greenhouses require very significant initial investments, including substantial and ongoing fuel costs, and more maintenance than unheated greenhouses. In contrast, less-expensive solar-heated greenhouses still have the advantage of an extended growing season over open-field cultivation. Earlier greenhouse planting and a longer harvest season generate their greatest profits when open-field produce is not available: either before open-field crops mature or after their season ends. Also, greenhouse working conditions (out of the weather) are less onerous than is the case with open-field cultivation.[9]

Another greenhouse advantage is a more dependable harvest via the elimination or major reduction in numerous risk factors.[10] Rarely is there damage from high winds and heavy rain; damage from predation of birds, rabbits, and deer is eliminated; with drier leaves, damage from foliar diseases is reduced; greenhouse irrigation renders vital watering more predictable and consistent; and properly maintained temperature, made possible in a greenhouse environment, can reduce crop loss from freezing and over-heating.[11]

Finally, the 2016 greenhouse project appears to have helped overcome some of the insular "silo" mentality to be found in some churches and ministries in the former Soviet Union. Participants in the Zaoksky training asked why an American wanted to help them. They also asked why a Methodist wanted to help Pentecostals, Baptists, and Nazarenes.[12] One pastor surviving on a very meager income was encouraged by the opportunity to participate in the greenhouse project, considering it "God's miracle" and "God's answer" to his family's great need. This pastor also found working in his greenhouse to be "a place of solitude for prayers to God."[13]

Jacob Mittleider and Greenhouse Cultivation

One impressive Russian effort at overcoming dependence upon outside support has been the Adventist seminary and farm at Zaoksky, near Tula. I first visited Zaoksky in 1993 where serious measures were already underway to achieve financial independence. Means to this end included traditional farming and greenhouse cultivation (for the benefit of the seminary cafeteria and for the sale of produce), a canning factory, and a printing press that prepared denominational literature and also accepted outside jobs.

From 1989 to 1995, Jacob Mittleider, a U.S. citizen of Russian-German heritage, volunteered his time on site to establish the Zaoksky farm. Over the course of 38 years Mittleider worked in 27 countries undertaking 75 gardening demonstration and training projects. He also wrote 10 gardening books, five of which have been translated into Russian. For his work at Zaoksky, one Russian agricultural university awarded Mittleider an honorary doctorate. According to Moscow's *Izvestiia* newspaper, Mittleider's garden at Zaoksky "looks like a work of art. The neighboring collective farm field is full of weeds, but here where the land is the same, you won't see a single weed."[14]

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[7] Cheryl Kaiser and Matt Ernst, *High Tunnel Overview*, University of Kentucky College of Agriculture, Food and Environment.
[8] Saha, *Protected Agriculture;* Jacob R. Mittleider, *The Mittleider Gardening Course*. Edited and revised by James B. Kennard. (Food for Everyone Foundation, 2014), 3 and 9.
[9] Saha, *Protected Agriculture*; Kaiser and Ernst, *High Tunnel Overview*, 6.
[10] Jacob Mittleider, *Greenhouses, Greenhouse Production Problems and How to Solve Them* (Salt Lake City, UT: Food for Everyone, 2000), 5.
[11] Saha, *Protected Agriculture*; Kaiser and Ernst, *High Tunnel Overview*, 5, "Greenhouses: How to Choose & Where to Buy," 2014, http://eartheasy.com/how-to-buy-a-greenhouse.html, p. 1.
[12] Sergiy Dzyba to author, 14 April 2016.
[13] Dzyba to author, 1 July 2016; Giblett to author, 14 October 2017.
[14] Mittleider, *Mittleider Gardening Course*, 5.

On a second visit to Zaoksky in September 2015, I met Dr. Alexei Chizov, who now heads the farm and the instructional program inaugurated by Jacob Mittleider. To date over one thousand people have completed the program, which includes extensive hands-on practice as well as classroom instruction.[15] The six participants in the 2016 greenhouse gardening project who studied at Zaoksky under Dr. Chizov for the month of March completed survey evaluations of the training. Rankings for the four instructors, based on a scale of 1 to 10, with 1 the lowest and 10 the highest score, averaged 7.2, 7.7, 8.1, and 9.6. Participant rankings averaged 7.9 for housing, 7.9 for the (vegetarian) cafeteria, 8.3 for the value of interaction among program students, and 8.3 for the helpfulness and efficiency of Zaoksky support staff. Rankings for the four course texts averaged 7.6 for *Poluchaem vysokii urozhai ovoshchei. 6 shagov uspeckha [We Obtained a High Yield of Vegetables. Six Success Steps]*; 8.6 for *Ogorodnichestvo. Kratkii kurs [Horticulture. Short Course]*; 8.9 for *Zdorovye ovoshchi [Healthy Vegetables]*; and 9.3 for *Vyrashchivaem pomidory [We Grow Tomatoes]*. When asked to rate the "overall degree to which you would recommend the Zaoksky program to others," survey respondent rankings averaged 7.6. Unfortunately, the participants from Selyshche and Bucha, Ukraine, were not greenhouse site directors, their communication of Mittleider cultivation methods to site directors were only marginally successful, and they had minimal involvement in work in their respective greenhouses. As a result, in some instances the adoption of Mittleider methods by greenhouse directors was partial or negligible.[16] As Mittleider's close associate, James Kennard, observed, some "people tend to hang on to what they 'know' even in the face of new and better information."[17]

In addition to the one-month Zaoksky greenhouse gardening course, I prepared a document for site directors entitled "A Greenhouse Garden Project in the Former Soviet Union: Goals, History, and Guidelines," which is available in Russian and English on the *East-West Church and Ministry Report* website: www.eastwestreport.org. This document and the present report are based upon a review of relevant published literature on greenhouse gardening and upon invaluable advice and counsel provided by four professors from the University of Kentucky College of Agriculture: Dr. Shubin Saha, Dr. Ray Smith, Dr. Brent Rowell, and Dr. Tim Woods. In addition, Christopher McKenzie from the Grow Appalachia program at Berea College, Berea, Kentucky, and James Kennard, Jacob Mittleider's successor and founder of the Food for Everyone Foundation, shared their greenhouse gardening expertise.

Cost Containment

Each of the five greenhouses in Ukraine is 40 square meters (431 square feet) in size—4 meters wide x 10 meters long (13 feet 8 inches x 32 feet 10 inches), while the two greenhouses in Ivanovo, Russia, taken together, total 40.8 square meters (439 square feet), each 3.4 meters wide x 6 meters long (9 feet 10 inches x 19 feet 8 inches). The Ukrainian greenhouses were purchased from Eko Teplitsa (http://teplitca.kiev.ua) and the Russian greenhouses from Zavod Teplits (msk.zavodteplic.com). For nominal additional cost the Ukraine greenhouse distributor erected five greenhouses in two to three days per site, while Ivanovo workers chose to erect their two greenhouses themselves. To encourage replication by even small-budget churches and ministries, greenhouses were purchased that are comparatively inexpensive (hence the relatively small size), that are durable (hence the rust- and corrosion-free galvanized steel framing and rigid, six-millimeter-thick [.24 inch] corrugated polycarbonate panels with ultra-violet [UV] ray inhibitor), and that have low overhead (hence no heating or electric fans or lights in order to minimize utility bills and maintenance costs).[18]

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[15] James Kennard to author, 21 September 2015.
[16] Dzyba to author, 15 September 2016.
[17] Kennard to author, 9 March 2016.
[18] http://teplica.kiev.ua; http://domteplic.ru/ivanovo/catalog/tep13.html.

Factors to consider in choosing a greenhouse vendor include cost, quality of materials, vendor's reputation for reliability, availability of desired models, and delivery and installation charges.

A key component of the project is gravity-fed drip irrigation, with a cost per site under $200 (13,500 rubles; 5,240 hryvnia). (All exchange rates are as of 31 March 2016.) The system uses a small electric pump to draw well water to an elevated plastic tank holding 200 liters (52.8 gallons). Drip lines run from the tank along each row of plants. Considered the most efficient means of watering greenhouse row crops, drip irrigation "Places water precisely near the base of each plant and only wets a small soil area, minimizes evaporation, and reduces foliar diseases caused by overhead sprinkler systems."[19]

Another means of containing costs was to opt for season extension of approximately three additional weeks in the spring and three in the fall, instead of year-round cultivation. Foregoing winter cultivation eliminates the need for expensive heating; and instead of electric fans, the greenhouses employ passive ventilation.

Significant quality control was enhanced in Ukraine with the help of Irina Dzyba, wife of Ukraine greenhouse project coordinator Sergiy Dzyba. Irina, who has nine years of greenhouse experience, grew seedlings with high-quality seed from a Dutch supplier for all five Ukraine sites. In addition to Sergiy Dzyba's careful oversight of Ukraine sites, monitoring for quality control was overseen by Orphan's Tree at the Ivanovo, Russia, site, and by my personal visits to all sites in July and October 2016.

Another key component of the project was detailed record-keeping which, in turn, was used to prepare the present report. The rationale for this emphasis was recognition that "The grower who does not keep records is committed to repeat the same errors over and over."[20] Data were collected on labor; soil composition and preparation; fertilizer, herbicide, and insecticide inputs; and yields. Only cucumbers and tomatoes were raised in 2016, partly because keeping records on only two crops facilitated more accurate data collection. Site directors were instructed to have every greenhouse worker fill out an "On Site Daily Garden Work Checklist," multiple blank copies of which were to be kept on location. These forms were to be collected and the data entered into the "Daily Garden Worker Calendar" section of a Greenhouse Garden Records Journal. (See Appendix II.) Data collection had to balance the procurement of accurate, detailed information on the one hand, with, on the other hand, not overwhelming greenhouse workers and site directors with overly burdensome record keeping. With accurate cultivation information being such a critical aspect of the project, a provision was made for a substantial financial stipend for site directors who submitted sufficiently detailed data on labor, other inputs, and yields. Even with this monetary incentive, obtaining detailed, accurate records proved to be a significant challenge, making some generalizations drawn from the records tentative, and seriously delaying the completion of the present report.

Each of the six sites received a one-time grant of $2,500 (168,750 rubles; 6,550 hryvnia). Direct expenses included $1,400 (94,500 rubles; 36,680 hryvnia) for each greenhouse and drip irrigation system and $300 (20,250 rubles; 7,860 hryvnia) for seed, fertilizer/soil mix, and tools. (The Ivanovo, Russia, site purchased two greenhouses which together are equivalent in size to each Ukraine greenhouse.) Non-material expenses included $200 (13,500 rubles; 104,800 hryvnia) for room and board at the Zaoksky, Russia, greenhouse cultivation training course (March 2016), $100 (6,750 rubles; 2,620 hryvnia) for transportation to and from Zaoksky, and a $500 (33,750 rubles; 13,100 hryvnia) stipend for each director who submitted sufficiently detailed records. (Zaoksky did not charge for instruction.)

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[19] D. Smeal, M.W. West, Z.F. Williams, M.K. O'Neill, K. Lombard, and R.N. Arnold, "Efficient Irrigation of Small Plots Using a Simple, Inexpensive Micro-irrigation System." 27 May 2015; http://irrigationmanagement.nmsu.edu/documents/proceedings-icasals2006.pdf.

[20] Nelson, *Greenhouse*, 481.

Size and Design

Factors that should determine the size of a greenhouse are 1) cost; 2) labor available to efficiently utilize a given greenhouse size; and 3) the amount of yield that can be consumed and/or effectively marketed. University of Kentucky horticulturist Richard Durham notes that "Beginning gardeners often overplant, and then they fail because they cannot keep up with the tasks required."[21] It is also important to keep in mind the availability and conscientiousness of those who will be tending the greenhouse. As regards work ethic, many Eurasians—and Americans—have a bias against farming as menial and unrewarding, an attitude that must be overcome for greenhouse gardening to be successful.[22] One of the most successful 2016 greenhouse site directors, who is now enthusiastic about gardening, shared that he previously denigrated farming as a "curse."[23]

Greenhouses typically have designations derived from their contour, the most common being Quonset (semi-circular) and gothic or A-frame (with peaked roof and, preferably, straight side walls).[24] The five greenhouses erected in 2016 in Ukraine are gothic-style, whereas the two smaller greenhouses erected in Ivanovo, Russia, are Quonset-style. The five Ukraine greenhouses have a peak height of 2.65 meters (8 feet 8 inches), and the two Russia greenhouses stand 2 meters (6 feet 7 inches) high. Gothic-style greenhouses have a number of advantages over the Quonset-style. They shed ice and snow more readily, and the straight sides common in gothic design "provide more usable growing space along the outer walls than the typical round Quonset."[25]

Placement, Orientation, and Pruning

It is best to place the greenhouse close to an owner's or a worker's residence in order to curb theft and vandalism. This placement also minimizes time and effort spent accessing the greenhouse site. The ideal location is on well-drained, level ground (reducing foundation costs, labor, and the possibility of flooding). The site should have easy access to water and electricity. Even without electric fans and lighting, sites need some electricity to pump water into holding tanks for gravity-fed drip irrigation, which is highly recommended.[26] In some less developed countries where electricity is absent, erratic, or prohibitively expensive, hand pumps sometimes serve in place of electric pumps.

Avoiding shading from trees increases a greenhouse's solar heating and eliminates the possibility of damage from falling branches. In addition, if the entrance is located opposite prevailing winds, heat loss is reduced in colder months when workers access the greenhouse. An ideal site is far enough from trees and structures to prevent shading but close enough to provide the advantage of a windbreak. Some experts recommend an east-west ridgeline orientation,[27] especially for higher Northern Hemisphere latitudes, which include the 2016 Ukrainian and Russian greenhouse sites located between latitudes 49˚ and 57˚. However, both Jacob Mittleider and University of Kentucky College of Agriculture's Dr. Shubin Saha recommend a north-south ridgeline orientation to facilitate even light exposure (morning sun for the east side and afternoon sun for the west side).[28] Whatever the orientation, shading is not a problem if a greenhouse in the Northern Hemisphere is located south of other structures and trees.

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[21] Richard Durham, ed. *Home Vegetable Gardening in Kentucky* (Lexington, KY: University of Kentucky College of Agriculture, 2014), 3.
[22] Amos Chapple and Ksenia Churmanova, "Sanctions and the Russian Farmer," Radio Free Europe/Radio Liberty, 2017.
[23] Maksim Shestakyv, Kozyatyn, Ukraine, 4 July 2016.
[24] Kaiser and Ernst, *High Tunnel Overview*, 2.
[25] Kaiser and Ernst, *High Tunnel Overview*, 2. Chris McKenzie, Grow Appalachia, Berea College, affirmed the same, 1 December 2015.
[26] Kaiser and Ernst, *High Tunnel Overview*, 4; Durham, *Home Vegetable Gardening*, 3.
[27] Nelson, *Greenhouse*, 30; Joe J. Hanan, *Greenhouses: Advanced Technology for Protected Horticulture* (New York: CRC Press, 1998), 31.
[28] Mittleider, *Mittleider Gardening Course*, 178; Saha to author, 12 October 2015.

Another recommendation is to place taller-growing plants, such as trellised cucumbers, in the center of the greenhouse and lower-growing plants, such as staked or trellised tomatoes, on the sides of the greenhouse to maximize light exposure for both crops and to allow more vertical space for taller-growing cucumbers.[29]

According to Mittleider, greenhouse orientation is not as important as making sure tall plants do not block sunlight for shorter plants: "Place short plants south or west of tall varieties. In this way, the shadows from tall plants will not interfere with the light needed by short plants."[30]

Maximum light exposure and optimal use of greenhouse space is achieved by staking and trellising plants to grow vertically.[31] Several specialists also stress the importance of this practice for easier care of plants and easier harvesting, for improved fruit quality, and for maximum yield per square meter/foot.[32] Other advantages of growing crops vertically include the extra light each plant receives and the reduction in mildew and trampling of plants underfoot.[33]

Optimal vertical growth requires judicious pruning to remove all leaves that touch the ground and all suckers (new shoots or buds that develop "where the leaf is attached to the main stem").[34] Pruning horizontal runners promotes the vertical growth of the main stem and prevents the development of so much foliage that light is cut off and the development of fruit is retarded.[35] The Selyshche, Ukraine, site did not prune enough foliage and as a result harvested fewer tomatoes than all but one other site.[36]

Framing and Foundation

Wood is often used as a framing material for greenhouses because of its ready availability and its low cost, but it is not recommended because of its tendency to rot, especially in the humid environment of protected agriculture. Plastic tube frames do not rot, and they are lightweight and relatively inexpensive, but they lack the strength of other framing materials. Aluminum is durable, lightweight, and long-lasting, but it lacks the strength of galvanized steel, the most highly recommended greenhouse framing material. Galvanized steel, used in all Ukraine and Russia greenhouses in 2016, provides maximum stability in heavy winds and storms. Like aluminum, it is very durable and long-lasting, but it does have the one disadvantage of greater weight, which is a factor in transport and assembly. On the other hand, galvanized steel is less expensive than aluminum. In addition, because of galvanized steel's strength, its use permits greater spacing between trusses perpendicular to the ridgeline, thereby blocking out less sunlight.[37] In summary, because of galvanized steel's durability, strength, and cost advantage over aluminum, it is the recommended and most cost-effective framing material in the long run.[38]

Preparing greenhouse foundations in 2016 averaged two days each, except at one hilly Ukraine site, where the preparation time and expense ($450/11,916 hryvnia) proved to be considerable. Paying the manufacturer to assemble greenhouses, which took an average of two days each, proved to be a modest, well-spent investment. In construction it is also important to ensure that the structure is well-anchored to prevent wind and storm damage.

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[29] Mittleider, *Mittleider Gardening Course*, 265.
[30] Mittleider, *Mittleider Gardening Course*, 70.
[31] Eliot Coleman, *The New Organic Grower: A Master's Manual of Tools and Techniques for the Home and Market Gardener* (White River Junction, Vermont: Chelsea Green Publishing, 1989), 302.
[32] Mittleider, *Mittleider Gardening Course*, 36; Kaiser and Ernst, *High Tunnel Overview*, 2.
[33] Mittleider, *Mittleider Gardening Course*, 36; Coleman, *New Organic Grower*, 302.
[34] Mittleider, *Mittleider Gardening Course*, 119 and 124.
[35] Mittleider, *Mittleider Gardening Course*, 123; Coleman, *New Organic Grower*, 302; Coleman, *The Winter Harvest Handbook: Year-Round Vegetable Production Using Deep Organic Techniques and Unheated Greenhouses* (White River Junction, Vermont: Chelsea Green Publishing, 2009), 102.
[36] Dzyba to author, 4 August 2016.
[37] Saha to author, 27 August 2015; McKenzie to author, 1 December 2015.
[38] Hanan, *Greenhouses* 45 and 49; "Greenhouses: How to Choose," 4; McKenzie to author, 1 December 2015.

Coverings

Historically greenhouses employed glass panels for covering.[39] Beginning in the 1950s flexible plastics increasingly replaced glass because of their low cost, their light weight, and their relative ease of installation. Polyethylene, first developed in England, has been used to cover greenhouses since the 1950s and has become the most widespread flexible plastic used in protected agriculture, much preferred today over mylar and vinyl.[40] Unfortunately, even with highly recommended ultra-violet ray inhibitor, polyethylene quickly becomes brittle and opaque. It typically lasts only one to three years, four to five years at best.[41]

Rigid plastic-panel polycarbonate has many advantages over flexible plastics. This lightweight material is strong, does not tear in high winds, is more resistant to storm and hail damage, is easily cut and installed, has very good light transmission, and darkens with age much more slowly than polyethylene.[42] While more expensive than flexible plastics, polycarbonate greenhouse covering is more cost-effective in the long run because of its greater longevity: four to five years at a minimum, "15 years or longer" according to one source.[43] Polycarbonate panels were used in all Ukraine and Russia greenhouses in 2016.

Growing and Transplanting Seedlings

To ensure quality control and the growth of hardy, disease-free plants, it is strongly recommended to grow one's own seedlings.[44] "Healthy seedlings, grown in a protected environment, have the advantage of fast germination and a well-developed root system."[45] Also, growing one's own seedlings in a prepared soil medium reduces damage from insects and disease. In addition, the use of one's own transplanted seedlings "makes it possible to raise two crops of some vegetable types in the same soil-bed during one growing season."[46] In summary, home-grown seedling transplants "are stronger and more vigorous; mature earlier; produce more uniform and larger yields; [and] cut costs on weed and insect control."[47]

In 2016, as noted, Irina Dzyba grew tomato and cucumber seedlings for all five Ukraine greenhouse sites. High quality seed, purchased from a Dutch company, was planted indoors in mid-March 2016, with seedlings delivered to the five Ukraine greenhouse sites 5-10 May. Using a seed soil mix purchased in Kyiv, Irina kept the temperature at 20˚ to 22˚ Celsius (68˚ to 71.6˚ Fahrenheit), with solar exposure up to 12 hours on sunny days.[48] (Hereafter Celsius is designated as C and Fahrenheit is designated as F.) For comparison, Mittleider recommends temperatures of 21˚ to 29˚ C (70˚ to 85˚ F) for seed germination. Irina planted seeds in bunches and after three weeks transferred individual seedlings into separate compartments of small plastic trays, which were then placed outside in low tunnels. A water-permeable cloth covering conserved heat within the low tunnels. A second layer of plastic, laid directly over the cloth, was used only during heavy rains. The average temperature in the low tunnel was 15˚ C (59˚F). One night the outside temperature dropped to 5˚ C (41˚F), but because of the coverings the seedlings were not damaged.[49]

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[39] Nelson, *Greenhouse*, 30.
[40] Nelson, *Greenhouse*, 35-36; Hanan, *Greenhouses*, 52.
[41] Nelson, *Greenhouse*, 35-36; Hanan, *Greenhouses*, 52; Saha to author, 27 August 2015; McKenzie to author, 1 December 2015; "Greenhouses: How to Choose," 3; "Greenhouse Covering Materials Comparison – Glass, Polycarbonate, Polyethylene, Fiberglass, Acrylic, and Vinyl," http://HomemadeHints.com; Saha, *Protected Agriculture*.
[42] McKenzie to author, 1 December 2015; "Greenhouses: How to Choose," 3.
[43] "Greenhouses: How to Choose," 4.
[44] Mittleider, *Mittleider Gardening Course*, 7; Coleman, *New Organic Grower*, 129.
[45] Mittleider, *Mittleider Gardening Course*, 33.
[46] Mittleider, *Mittleider Gardening Course*, 33; Coleman, *New Organic Grower*, 130.
[47] Mittleider, *Mittleider Gardening Course*, 34; Coleman, *New Organic Grower*, 129-30.
[48] Dzyba to author, 2 July 2016.
[49] Dzyba to author, 2 July 2016.

Mittleider recommends that seedlings receive a heavy watering just prior to transplanting: "Wet soil hydrates the plant and keeps the root ball from falling apart when taken out of the pot. Transplant seedlings as early in the day as possible to reduce transplant shock."[50] Mittleider also recommends fertilizing and thorough watering to dissolve the fertilizer immediately after transplanting. As for spacing of transplants, Mittleider recommends 23 centimeters—cm hereafter—(9 inches) between cucumber seedlings and 22 to 35.6 cm (9 to 14 inches) between tomato seedlings, whereas horticulturalist Richard Durham recommends 61 to 91.4 cm (24 to 36 inches) between cucumber seedlings and 61 cm (24 inches) between tomato seedlings. As for spacing between plant rows within the greenhouse, Durham and Mittleider recommend 76 to 107 cm (30 to 42 inches), while gardening authority Eliot Coleman recommends 51 cm (20 inches) for cucumbers and 152 cm/1.52 meters (60 inches) for tomatoes.[51] Spacing between plants in the six greenhouse sites in 2016 averaged 8.9 inches and spacing between rows averaged 28.9 inches.

Soil Preparation

Focused attention to soil preparation is another factor contributing to the increased yields associated with greenhouse cultivation. Jacob Mittleider places great value in "custom-made soil mixes" held in place by 45.7 cm-wide (18-inch) elevated wooden grow boxes which keep soil in place and concentrate water and fertilizer close to plant roots. (Rototillers can be labor saving compared to hand tillers, but they are impossible or impractical for use in Mittleider grow boxes; they add to initial costs; they incur the ongoing expense of gas; and they require maintenance.) Some of the advantages of custom-made soil include improved "drainage and aeration for roots and balanced feeding of plants"; an extended growing season because "artificial soils warm up quickly in springtime, boosting growth"; fewer weeds; and water conservation because water penetrates artificial soil "uniformly, easily, and quickly."[52]

Soil mixtures that Mittleider recommends include various combinations of sawdust (aged better suited than fresh, but not walnut), clean concrete sand, rock wool (a mixture of ground basalt and chalk), Perlite (a naturally occurring soil amendment to prevent soil compaction), bark, man-made polystyrene amendments such as Styrofoam, and peat moss.[53] Light tan to brown sphagnum peat moss is the least decomposed and rarely used in greenhouse soil mixes.[54] Examples of suggested soil mixes (to be measured by volume, not weight) include 75 percent peat moss and 25 percent sand; 75 percent sawdust and 25 percent sand; 50 percent peat moss or sawdust, 35 percent sand, and 15 percent Perlite; and 50 percent sawdust, 25 percent sand, and 25 percent Styrofoam pellets.[55]

It should be noted that Dr. Shubin Saha, Dr. Brent Rowell, and Dr. Ray Smith from the University of Kentucky School of Agriculture all advise against the use of sawdust because its decomposition draws nitrogen from the soil mix that plants require. However, if sawdust is to be used, Smith notes that the less acidic it is, the better. He also notes that use of aged sawdust is better than fresh because it is less acidic. Even though for decades Jacob Mittleider had solid success using a sawdust component and even though the Kozyatyn site also had success using sawdust in 2016, other Mittleider-recommended mixtures, such as peat moss and sand, may be employed without the use of sawdust. Still, as horticulturalist James Kennard notes, "Kozyatyn used sawdust and sand and had the highest yields [of the six sites], which is evidence of Mittleider's claim that those ingredients are okay to use."[56]

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[50] Mittleider, *Mittleider Gardening Course*, 41.
[51] Mittleider, *Mittleider Gardening Course*, 42, 55, 67, 235; Durham, *Home Vegetable Gardening*, 9; Coleman, *New Organic Grower*, 132.
[52] Mittleider, *Mittleider Gardening Course*, 83 and 67.
[53] Mittleider, *Mittleider Gardening Course*, 179-80.
[54] Nelson, *Greenhouse*, 148-49.
[55] Mittleider, *Mittleider Gardening Course*, 84 and 180.
[56] Kennard to author, 18 October 2017.

In actual practice in 2016 only two Ukraine sites used a Mittleider-recommended soil mix: Kozyatyn and Potiivka (sawdust and sand). The other three Ukraine sites used black soil and Mittleider fertilizer mixes (Bucha and Min'kivtsi) or black soil and horse manure (Selyshche). It should be noted that Mittleider advises against the use of composted organic materials "because it is difficult to determine what amounts of specific nutrients" they contain. Mittleider and Saha also advise against the use of compost because it contributes to plant diseases, insect infestation, and increased weeds.[57] While Mittleider and Saha advise against the use of manure, horticulturist Eliot Coleman recommends its use.[58]

Ventilation

To minimize cost, the seven greenhouses erected in Ukraine and Russia in 2016 employ passive ventilation. As previously stated, the goal is to extend the growing season in the spring and fall, rather than grow plants through the winter, which would require costly fueled heat. Given passive ventilation, the ideal greenhouse design utilizes a maximum number of openings for air circulation: ridge vents, roll-up sides and end walls, and large windows and doors.[59] The gothic design of the Ukraine greenhouses includes ridgeline vents the length of the structures, end wall windows, and one door. With only end wall windows, one door, and lower height, the two Quonset design greenhouses in Ivanovo, Russia, permit less ventilation.

With overheating a primary factor in plant failure in greenhouses, the opening and closing of vents, based upon close, daily monitoring of temperature, is essential.[60] Thermometers, both inside and outside the greenhouse, are highly recommended. The temperature inside the greenhouse should obviously be kept above freezing (0˚ C; 32˚ F) and no warmer than 32˚ C (90˚ F). According to Mittleider, the ideal temperature for optimal growth is 21.1˚ to 30˚ C (70˚ to 90˚ F).[61] For growing greenhouse tomatoes, Coleman considers a night temperature of 17˚ C (62˚ F) as optimal, and he recommends opening vents when the greenhouse temperature reaches 24˚ C (75˚ F).[62]

Closing vents in colder weather and opening them in warmer weather is a critical, daily task that cannot be overemphasized. On the days of my visits to Ukraine sites (30 June-4 July 2016), the temperature was above, or well above, the maximum tolerable temperature inside four of the five greenhouses: Min'kivtsi: 33˚ to 35˚ C (91˚ to 95˚ F); Kozyatyn: the site director said he "tried to keep the temperature under 40˚ C (104˚ F)"; Bucha: 42˚ C (108˚ F); Potiivka: 50˚-53˚ C (122˚-127˚ F). (The Selyshche site submitted records that lacked notations for ventilation for five consecutive days [11-15 June]. One must assume either less than complete record keeping or significant harm to plants in an overheated greenhouse.)

Mittleider proponent James Kennard of Food for Everyone stresses "ample ventilation as the first, and usually the only necessary, defense against excessively hot temperatures."[63] In the future, in addition to maximum use of ventilation on hot days, these sites may still need to consider the use of a shading material over the greenhouse and/or electric fans. Dr. Ray Smith from the University of Kentucky notes that a greenhouse white paint is available that does not wash off with rain, but which comes off easily with soap and water. The financial and labor cost of these various cooling options need to be weighed against the value of the projected increase in yield to be derived from more optimal temperatures inside greenhouses.

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[57] Mittleider, *Mittleider Gardening Course*, 5; Saha to author, 14 October 2015.
[58] Coleman, *New Organic Grower*, 301; Coleman, *Winter Harvest Handbook*, 101-02.
[59] Saha, *High Tunnel Crops*; United States Department of Agriculture Natural Resources Conservation Service, "Kentucky NRCS Seasonal High Tunnel Initiative." 2015; James B. Kennard, "Greenhouse Plans." Click "freebies" on the homepage: http://growfood.com/shop/.
[60] "Greenhouses: How to Choose," 2; Kaiser and Ernst, *High Tunnel Overview*, 5.
[61] Mittleider, *Mittleider Gardening Course*, 179.
[62] Coleman, *New Organic Grower*, 311.
[63] Kennard to author, 18 October 2017.

Watering

Components of the gravity-fed drip irrigation systems employed in the five Ukraine greenhouses include an electric pump for drawing well water, hosing, a 200 liter (52.8-gallon) holding tank, and drip lines, costing in total a modest $130 to $200 per site (8,775 to 13,500 rubles; 3,406 to 5,240 hryvnia). Placing holding tanks on platforms only 1.2 to 1.8 meters (four to six feet) above the ground proved adequate to deliver water through gravity-fed drip lines to all plants.[64] The manufacturer who erected the Ukraine greenhouses also installed the irrigation systems.

Proven benefits of gravity-fed drip irrigation over hand-watering or sprinkler systems include "higher yields, improved product quality, and reduced incidence of…diseases."[65] By not wetting foliage with sprinklers, problems with plant diseases, such as mildew and mold growth on leaves, are reduced.[66] Drip irrigation, with lines running along plant stems, also assists in weed control by reducing water available to unwanted plants. Another advantage is that drip irrigation requires much less labor than hand watering, and much less water than sprinkler systems, thus prolonging the life of pumps and reducing the use of electricity.[67] Underscoring this point, one 2010 research study concluded that widespread adoption of drip irrigation in greenhouse cultivation had resulted in very significant "improvement in water use efficiency and energy savings."[68] Finally, drip irrigation permits the even application of soluble fertilizer with minimal additional labor, although this method of fertilizer application was not employed in the Ukrainian and Russian greenhouses in 2016.[69]

The value of drip irrigation, however, can be compromised. Dr. Paul Nelson, horticulture specialist at North Carolina State University, notes that "loss in crop quality" in greenhouses occurs most often when watering is not performed with great care. If it is done at the wrong time or in the wrong amount, plants will be damaged and quality and yield reduced, although the same is also true with sprinkler systems and hand-watering.[70] Care also has to be taken to keep drip line emitters (openings) from becoming clogged, which is particularly a problem if unfiltered water high in contaminants is used in irrigation.[71] Uneven water flow through Potiivka drip lines in 2016 may have been caused by clogged emitters.

Watering by any method, though absolutely critical, can become so routine, and even boring, that it is not always given the careful, consistent attention it deserves.[72] In addition, with an irrigation system, the electric pump requires a watchful eye. Theft of the pump at the Kozyatyn, Ukraine, site required daily movement of its replacement from house to well to house for every watering. Finally, some gardeners find it difficult to believe that the slow drip of gravity-fed lines can possibly supply enough water to greenhouse plants, hence the need for education and demonstration to underscore the value of drip irrigation.[73] Perhaps this is the reason the site director of the Ivanovo greenhouses failed to install drip irrigation in 2016. As a result, at this site the labor input from hand watering was very high and yield significantly lower than at Ukraine sites that installed drip irrigation. (The Ivanovo site did install drip irrigation for the 2017 growing season.)

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[64] Brent Rowell and March Lar Soe, "Design, Instruction, and Extension of Low-Pressure Drip Irrigation in Myanmar," *HortTechnology* 25 (August 2015), 430.
[65] Rowell and Soe, "Design," 422. See also Salvador J. Locascio, "Management of Irrigation for Vegetables: Past, Present, and Future," *HortTechnology* 15 (July-September 2005), 482.
[66] Hanan, *Greenhouses*, 335; Mittleider, *Mittleider Gardening Course*, 44; Locascio, "Management," 484.
[67] Mittleider, *Mittleider Gardening Course*, 80; Rowell and Soe, "Design," 422; Locascio, "Management," 484-84; Hanan, *Greenhouses*, 335; Brent Rowell and March Lar Soe, *Easy Watering in Six Steps: Drip Irrigation Installation Guide*. 4th ed. (Yangon, Myanmar: Proximity Designs, 2012).
[68] National Research Council, *Toward Sustainable Agricultural Systems in the 21st Century* (Washington, DC: National Academy Press, 2010); Rowell and Soe, "Design," 422.
[69] Locascio, "Management," 483-84.
[70] Nelson, *Greenhouse*, 203.
[71] Smeal, "Efficient Irrigations," 51.
[72] Nelson, *Greenhouse*, 203.
[73] Rowell and Soe, "Design," 433 and 436; Locascio, "Management," 483.

Frequency of watering is another important consideration. It should occur at least daily, ideally early in the morning "when the warm air can absorb moisture from wet surfaces," thereby reducing humidity and mildew in the greenhouse.[74] Watering frequency in the 2016 greenhouse sites varied a great deal, far more so than advisable. The Kozyatyn, Ukraine, site watered twice daily (a good idea), while most other Ukraine sites watered once a day, as recommended by Mittleider.[75] Unfortunately, Min'kivtsi, Ukraine, watered only every other day, not enough for maximum quality and yield.[76]

For greenhouse row crops Mittleider favors elevated boxed frames to maximize the benefit of drip irrigation and fertilizing inside the box and to reduce the growth of weeds outside the box. The Min'kivtsi, Ukraine, site did not build plant boxes and the Ivanovo, Russia, site plant boxes were not raised above natural ground level; the result was reduced yield.[77]

Fertilizing

One means of determining what type of fertilizer to use is a test to determine soil pH level. "The symbol pH is used to express a measure of the acidity or alkalinity of a soil."[78] Its scale runs from 0 to 14, with a pH of 7 being neutral. Below 7 indicates how acidic, and above 7 how alkaline, is a given soil. A pH of 6.2 to 6.8 is recommended for growing most crops.[79] As helpful as determining a soil's pH may be, many growers do not test soil because of the expense.[80] All 2016 greenhouse sites did test for pH.

The essential plant nutrients are nitrogen, potassium, phosphorus, calcium, magnesium, sulfur, chloride, iron, nickel, manganese, boron, zinc, copper, and molybdenum.[81] Plants require the first three in the largest volume, and fertilizer is sold according to the percentage of these nutrients in a given mix. Thus, 16-16-16 contains 16 percent each of the primary nutrients of nitrogen, phosphorus, and potassium. Mittleider recommends this store-bought mix, but if unavailable, 15-15-15, 17-17-17, or 20-20-20 can serve as alternatives, in that order. At the same time it is important to remember that the other nutrients are also essential, but in very small quantities, which can easily be supplied with a water-soluble fertilizer or composted manure.

Mittleider also advises growers to consider mixing their own fertilizer blends: 1) a pre-plant fertilizer mix in proportions of 2.3 kilograms—hereafter kg—(5 pounds) of lime or gypsum, 113.4 grams—hereafter g—(4 ounces) of magnesium sulfate, and 28.3 g (1 ounce) of boron; 2) a transplant fertilizer mix consisting of 7.1 g (one-quarter ounce) of nitrogen fertilizer per 30.1 centimeters (foot) of crop; and 3) a weekly fertilizer mix in 11.3 kg (25 pound) proportions as follows: 4.8 kg (10 pounds 8 ounces) of ammonium nitrate, 2 kg (4 pounds 8 ounces) of phosphorus, 2.7 kg (6 pounds) of potassium, 1.7 kg (3 pounds 12 ounces) of magnesium sulfate, 85 g (3 ounces) of boron, 56.7 g (2 ounces) of manganese, 113.4 g (4 ounces) of zinc, 14.2 g (½ ounce) of copper sulfate, and 7.1 g (¼ ounce) of molybdenum. A short-term weekly fertilizer substitute mix combines 2.7 g (6 pounds) of 16-16-16 fertilizer, .45 kg (1 pound) of magnesium sulfate, and 5 g (18 ounces) of boron.[82]

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[74] Nelson, *Greenhouse*, 424. See also Smeal, "Efficient Irrigation," 51.
[75] Mittleider, *Mittleider Gardening Course*, 43. See also Locascio, "Management," 483.
[76] 4 July 2016 site visit; Nelson, *Greenhouse*, 203.
[77] 4 July 2016 site visit.
[78] Mittleider, *Mittleider Gardening Course*, 153.
[79] Nelson, *Greenhouse*, 148 and 227; Durham, *Home Vegetable Gardening*, 4.
[80] Igor Streljok, "IFC Initiative – Greenhouse Sector Study: the Ukraine," International Finance Corporation: World Bank Group, December 2011.
[81] Ben Potter, "Can You Name All 17 Essential Plant Nutrients?" 9 July 2013; https://www.agweb.com/articles/can_you_name_all_17_essential_plant_nutrients/.
[82] Mittleider, *Mittleider Gardening Course*, 49, 51, and 53-54.

Mittleider gives the following directions for fertilizer applications. Before planting, thoroughly mix into the soil 28.4 g (one ounce) per 30.5 centimeters (foot) of pre-plant fertilizer and 14.2 g (½ ounce) per 30.5 centimeters (foot) of the weekly fertilizer mix. "After transplanting seedlings, apply 7.1 g (¼ ounce) per 30.5 centimeters (foot) of a nitrogen fertilizer in a narrow band" along each plant row, taking care to avoid plant stems. "Water promptly, thoroughly soaking the soil-bed to dissolve the granular fertilizer and keep plants from wilting."[83] "Apply the first full weekly fertilizer mix three days after transplanting and every seven days thereafter."[84] Mittleider recommends 8 to 12 weekly fertilizer applications for trellised cucumbers, 6 to 8 applications for determinate (bush) tomatoes, and 10 to 12 applications for indeterminate tomatoes. (Determinate tomatoes attain a compact height of approximately 1.2 meters [4 feet] and ripen in a short time span, usually within a two-week period. Indeterminate (vining) tomatoes—preferred for greenhouse cultivation—typically grow to 1.8 meters [6 feet] or more with pruning, and their fruit ripens throughout the growing season.)[85] The 2016 greenhouse sites varied in the degree to which they followed the Mittleider fertilizer regimen: Selyshche not at all, while Bucha, Kozyatyn, and Potiivka applied the weekly Mittleider fertilizer mix every 10 days, instead of every 7 days.

Controlling Weeds, Plant Diseases, and Insects

Controlling weeds, plant diseases, and insects obviously improves crop quality and yield. Since greenhouses provide a rich environment for these unwanted interlopers, concerted efforts are required to combat them. Eliminating weeds helps control diseases and insects, and one way to reduce weeds is *not* to use mulch. Growers employ mulch to retain soil moisture, but it is a haven for diseases and weed seed and is not recommended. One alternative is to lay black plastic between plant rows. To combat weeds, growers should also remove all plant debris from greenhouses and should reduce, or better yet, eliminate vegetation close to greenhouses. Another recommended practice is to root out weed rhizomes (horizontal underground stems) and stolons (above ground runners) when preparing the greenhouse soil mix for transplants.[86] As regards weeding, the Bucha site, for some reason, spent dramatically more time on this activity (17.6 hours), compared to other sites which averaged 1.8 hours of weeding for the season. Horticulturalist Kennard considers time spent on weeding at Bucha excessive: "No wonder some people think gardening is a curse."[87]

Planting the same crops in the same soil year after year increases plant diseases and insect infestations and reduces yield.[88] Physically moving greenhouses is an option, though labor intensive. Reducing the danger of disease by growing one's own seedlings is highly recommended. Soil sterilization (solar heating of soil under plastic to kill harmful microorganisms) is another option, one which, however, requires considerable expense, labor, and expertise.[89] Regular inspection of plants, including the underside of leaves, which insects favor, is highly recommended. This "scouting," as plant inspection is sometimes called, should be a daily routine and, to save time, can be done while drip irrigation is in process.[90]

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[83] Mittleider, *Mittleider Gardening Course*, 49 and 42.
[84] Mittleider, *Mittleider Gardening Course*, 55.
[85] Mittleider, *Mittleider Gardening Course*, 236; "What is the Difference between Determinate and Indeterminate Tomatoes?" 1 January 2013; faq.gardenweb.com/discussions/2766765.
[86] Mittleider, *Mittleider Gardening Course*, 52, 119, 155-56, and 264; Mittleider, *Greenhouse Productions*, 7; Shubin Saha, *High Tunnel Crops*, Department of Horticulture, University of Kentucky College of Agriculture, Food, and Environment, 2014; Nelson, *Greenhouse*, 422.
[87] Kennard to author, 18 October 2017.
[88] Kaiser and Ernst, *High Tunnel Overview*, 3; Saha, *High Tunnel Crops*.
[89] Saha, *High Tunnel Crops*; Shubin Saha and Dan Engel, "Soil Solarization for High Tunnels," Horticulture Department Fact Sheet 7003, University of Kentucky College of Agriculture, Food, and Environment; Mittleider, *Mittleider Gardening Course*, 172; Mittleider, *Greenhouse Production*, 8.
[90] Kaiser and Ernst, *High Tunnel Overview*, 6; Mittleider, *Mittleider Gardening Course*, 166.

Careful adherence to practices of sanitation is the best, lowest-cost means of combating weeds, plant diseases, and insects.[91] Anything or anyone in contact with potentially disease-prone or insect-infested vegetation or weed seed outside the greenhouse should be cleaned (sterilized) before entering the greenhouse. Better yet and more practical, growers should consider dedicating sets of tools, clothes, and shoes for exclusive use inside the greenhouse, exercising care not to transport any of the above back and forth, outside and inside, the greenhouse.[92] To my knowledge, only the Potiivka greenhouse site attained this level of sanitation in 2016.

If growers opt for organic gardening, their harvest will command higher prices, and not using herbicides and pesticides eliminates many safety concerns. In the case of traditional gardening, various measures, already discussed, can greatly reduce damage from plant diseases and insects. Still, in traditional gardening herbicides and pesticides are sometimes required to prevent serious crop damage. In such cases, safety in handling chemicals is essential.[93] Detailed safety guidelines should be followed as outlined in "A Greenhouse Garden Project in the Former Soviet Union: Goals, History, and Guidelines," which is available in Russian and English at www.eastwestreport.org. Following are a few of this document's key recommendations:

1. Use of herbicides and pesticides "should be in the hands of one carefully trained for the job;[94]
2. Chemicals should be stored in "a well ventilated, locked" space at a temperature between 4˚ and 32˚ C (39˚ and 90˚ F);[95]
3. It is best to dispose of these chemicals after one year because over time they lose their effectiveness, or even "become toxic to plants;"[96]
4. Empty herbicide and pesticide containers should not be used for any other purpose;[97]
5. By all means employ protective gear: goggles, broad-brimmed plastic rain hat, rubber gloves and boots, waterproof rubber or synthetic rubber suits covering arms and legs, and, if possible, a chemical cartridge respirator;[98]
6. After use of chemicals, wash thoroughly. Never eat, drink, or use the bathroom before washing. Wash clothes separately from family wash and air dry outside. Even after cleaning, store all protective gear outside living quarters. In addition to "A Greenhouse Garden Project," two other documents are highly recommended for those who read English: "Avoiding Exposure: Protective Clothing" (Cornell University, Pesticide Management Education Program; http://envirocancer.cornell.edu/FactSheet/General/fs21.exposure.cfm); and "Pesticides: Application Equipment" (AZ Master Gardener Manual: Using Pesticides Safely; http://arizona.edu/pubs/garden/mg/pesticides/safely.html).

Unfortunately, both in the former Soviet Union and in the United States, a big gap exists between agricultural best practices and government regulations on the one hand, and careless use of chemicals on the other.[99]

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[91] Saha to author, 5 January 2016.
[92] Mittleider, *Mittleider Gardening Course*, 171-73; Nelson, *Greenhouse*, 420.
[93] Mittleider, *Mittleider Gardening Course*, 135.
[94] Nelson, *Greenhouse*, 394.
[95] Nelson, *Greenhouse*, 394; Mittleider, *Mittleider Gardening Course*, 166.
[96] Nelson, *Greenhouse*, 394.
[97] Nelson, *Greenhouse*, 403.
[98] Nelson, *Greenhouse*, 396; Saha to author, 5 January 2016.
[99] Saha to author, 5 January 2016; "Health Rules and Requirements during Transportation, Storage, and Use of Pesticiddes," #86/95, Ukraine; Ukrainian Agribusiness Club, *The Greenhouse Sector in Ukraine*, 2012.

The Harvest

In 2016 Ukraine and Russia greenhouse sites raised only cucumbers and tomatoes for several reasons. These vegetables are very popular with consumers.[100] Most gardeners already have considerable experience growing these vegetables. In addition, cucumbers begin bearing quickly after seedlings are planted (within 44 to 65 days) and can provide continuous yield over a span of 3 to 4 months.[101] Tomatoes have a high yield per plant for the space they occupy, and they "grow under a wide range of conditions."[102] Finally, a key goal of the project was to have growers closely document their labor inputs, costs, and yield for the purpose of sharing successes (and failures) with potential growers who might benefit from lessons learned. To that end, detailed documentation through careful record-keeping was simplified by planting only two crops in the 2016 growing season.[103]

On my visit to Ukraine sites in late June-early July 2016, even before tomatoes had ripened, I observed a steady harvest of cucumbers already in progress. By the time of my visit on June 30, Selyshche had been harvesting 10 kilos (22 pounds) of cucumbers daily for three weeks. By July 2, Bucha's yield of cucumbers was 10 to 15 kilos (22-33 pounds) per day. By July 4, Kozyatyn had been harvesting 10 kilos (22 pounds) of cucumbers per day for a month. At Min'kivtsi, 22 days after planting, harvesting of cucumbers began at a rate of 2 to 3 kilos (4.4 to 6.6 pounds) per day, and by July 4 this site's cucumber yield was averaging 15 kilos (33 pounds) per day—and all this in 40-square-meter (430.6 square foot) greenhouses.

For maximum cucumber yield, once they reach sufficient size, they should be harvested daily.[104] If cucumbers are allowed to grow much larger than two to three fingers in width (as was the case at Ivanovo), they collectively place undue strain on vines, they can be bitter, and total yield is significantly reduced.[105]

The contrast between open-field and greenhouse cultivation was dramatic. At Selyshche, where by 30 June greenhouse cucumbers were being harvested at a rate of 10 kilos (22 pounds) per day, cucumber vines growing just outside the greenhouse were mostly leaves with practically no yield. The Selyshche site director reported that by late June his neighbors were coming by the greenhouse to see how he was growing cucumbers, a good illustration of the educational value of the greenhouse project. At Potiivka, too much rain and high temperatures killed cucumber vines in open fields, whereas the greenhouse yield by 30 June was such that the site director was able to give cucumbers to needy people in his village every other day. At the same time, cucumbers selling in the local market "were as pricey as bananas."

Participants in the 2016 greenhouse project were given full freedom to utilize their harvest as they saw fit. Most sites used the produce to provide for their family's or their ministry's personal needs. At Bucha, the 2016 harvest was sufficient to provide cucumbers and tomatoes for 100 recovering alcoholics in five rehabilitation centers. All the other greenhouse sites were able to donate produce to church members, neighbors, and relatives, in addition to fulfilling their personal and ministry requirements. As an indicator of the summer 2016 greenhouse bounty, the Selyshche site, with its foster family of 14, averaged a bucket of fresh vegetables daily and 260 liters (69 gallons) of canned vegetables for the season.

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[100] Igor Streljok, "IFC Initiative – Greenhouse Sector Study," International Finance Corporation: World Bank Group, December 2011, 2; Coleman, *New Organic Grower*, 310.
[101] Durham, *Home Vegetable Gardening*, 14 and 34; Kennard to author, 18 October 2017.
[102] Durham, *Home Vegetable Gardening*, 42.
[103] Streljok, "IFC Initiative," Streljok, "IFC Initiative—Ukraine," Alexei Chizov to author, 10 September 2015.
[104] Coleman, *Winter Harvest Handbook*, 102.
[105] Coleman, *New Organic Grower*, 302.

Finally, Kozyatyn's sale of produce proved quite successful. In this village, open-field cucumbers had a bitter taste, unlike those from the Kozyatyn greenhouse, whose cucumbers sold out quickly for a good sum before open-field harvest depressed the price. Kozyatyn's 2016 profits enabled the purchase of a second, smaller greenhouse which permitted the planting of almost twice as many seedlings in 2017.

One major reason greenhouse yields outstrip open-field yields is that the protected growing environment makes it possible to have second plantings and harvests in a single season.[106] Profits from greenhouse produce are higher than profits from open-field produce, not only because of higher quality, but also because greenhouse vegetables command premium prices in the early spring and late fall when they have no competition from open-field crops, which either are not yet ripe or are already finished for the season.[107]

Marketing

In 2016 five of the six greenhouse sites utilized their harvest exclusively for donations and to supplement the diet of ministry clients (Bucha—alcohol rehab centers; Selyshche—14-member Christian foster home; Ivanovo—orphan graduate ministry center) or to feed the families of bi-vocational pastors (Min'kivtsi and Potiivka). While only one bi-vocational pastor (Kozyatyn, Ukraine) sold greenhouse produce in the local market, all site directors anticipated doing so in the future.

Factors that determine the success or failure of greenhouse marketing fall into two categories: those beyond the control of local growers and those that local growers can independently manage to their benefit. Imponderables in the first category include fuel and utility costs, international developments affecting trade such as sanctions, and various other government policies such as protective tariffs and state-subsidized loans and capital incentives. One recent example of a development beyond the control of local growers has been Western trade sanctions in response to Russia's annexation of Crimea and its support for separatists in Eastern Ukraine, with Russia's ban on Western food imports in response.[108] The Russian embargo on Western foodstuffs has increased the profitability of produce from Russian greenhouses, while at the same time disrupting normal Russian-Ukrainian trade, including a sharp decline in Ukrainian tomato exports to Russia.[109]

Such political developments as the ongoing Ukrainian-Russian conflict are clearly unpredictable and beyond growers' control. At the same time, greenhouse gardeners can make decisions that significantly affect successful marketing of their harvest. They can choose to grow tomatoes and cucumbers, which are especially popular with consumers, are highly profitable, and are relatively inexpensive to raise. They can clean produce for eye appeal and sell the most attractive produce while saving misshapen or undersized yield for personal use.[110] They can choose sale locations based upon high traffic and security. But by far the most profitable marketing decision greenhouse growers can make is to cultivate a double crop that can be harvested for sale in both early spring and late fall when greenhouse yield does not face competition from open-field harvest.[111]

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[106] Streljok, "IFC Initiative;" Streljok, "IFC Initiative—Ukraine, 2-3.
[107] Streljok, "IFC Initiative—Ukraine," 3; Coleman, *New Organic Grower*, 130; Kaiser and Ernst, "High Tunnel Overview," 1; Saha to author, 5 January 2016.
[108] Streljok, "IFC Initiative;" "Anti-West Boycott Hits Russian with 31% Food Price Hike," *Moscow Times*, 2 August 2016; Maria Karnaukh, Grants Worth $23,000 to Give Russian Farmers a Boost." *Russia Beyond the Headlines*, 10 August 2015; Olga Samofalova, "Food Import Substitution Turns Out To Be Extremely Profitable." *Russia Beyond the Headlines*, 9 February 2017.
[109] Dorian Jones and Elizabeth Owen, "Turkey and Russia: History Fuels Rancor," *Moscow Times*, 2 March 2016.
[110] Mittleider, *Mittleider Gardening Course*, 115; Tim Woods, "High Tunnel Economics and Marketing," University of Kentucky College of Agriculture, Food, and Environment; Woods to author, 5 January 2016.
[111] Kaiser and Ernst, *High Tunnel Overview*, 1-2; Saha, *High Tunnel Crops*; Mittleider, *Greenhouse Production*, 8; Streljok, "IFC Initiative;" Streljok, "IFC Initiative—Ukraine;" Olga Booylova, "Review of Russian Market of Fresh Vegetables," *Russian Food Market* (No. 4, 2015); www.foodmarket.spb.ru/eng/current.php?article=1088.

Circumstances in Ukraine and Russia suggest a solid future for greenhouse cultivation and sales. Both countries recognize the benefits of state support for the agricultural sector. Ukraine has the benefit of favorable climate (especially in the south), a large domestic market, large export potential to the European Union, and low labor costs.[112] As for Russia, Western sanctions, coupled with the Kremlin's agricultural embargo in response, spell new opportunities and higher profits for greenhouse growers. In addition, Russian analyst A.T. Tsydendambaev notes "considerable growth potential, as average consumption of cucumbers and tomatoes in Russia is much lower than nutritional recommendation.[113]

Ivanovo's Handicaps—And Overcoming Them

Some factors contributing to the lower Ivanovo greenhouse yield in 2016 were beyond the director's control. Other detrimental factors can be attributed to the choice of a less than optimal Quonset greenhouse design. Finally, some inadvisable cultivation practices at Ivanovo were corrected in 2017, facilitating an improved harvest.

1. The new Orphan's Tree Ministry Center in Ivanovo was completed so late in the spring of 2016 that the site's two greenhouses adjacent to the ministry center could not be erected in a timely fashion.
2. The colder Ivanovo latitude (57˚ North), compared to the 49˚ to 50˚ North latitudes of Ukraine sites, creates a greater challenge for cultivation in unheated greenhouses.
3. The lower height of the Ivanovo greenhouses (2 meters [6 feet 7 inches] versus 2.6 meters [8 feet 8 inches] in the Ukraine greenhouses) presents a greater challenge in ventilation and temperature control.
4. Useable space for cultivation in Ivanovo's two Quonset-style greenhouses is less than in Ukraine's gothic-style greenhouses because the perpendicular sides of Ukraine's gothic-style greenhouses provide more growing space than the curved sides of Quonset-style greenhouses. And two Quonset-style greenhouses eliminate more growing space than one larger Quonset-style greenhouse: thus, Ivanovo's more restricted space.
5. Ivanovo's greenhouses have fewer vents than the Ukraine greenhouses, making heat buildup more of a challenge.
6. Unfortunately, the Ivanovo greenhouses are partially shaded by the new two-story ministry center, reducing hours of solar heating per day.
7. All Ukraine sites installed drip irrigation, but this was not the case at Ivanovo in 2016. As a result, hand-watering at Ivanovo was unquestionably much more labor intensive.
8. As Mittleider recommends, Ivanovo did construct wooden grow boxes, but these were not elevated to retain water and fertilizer close to plant roots.
9. Ivanovo harvested quite large cucumbers, whereas total yield is documented to be much greater when cucumbers are harvested daily, ideally at a two- or three-finger-width size. Smaller cucumbers are also preferable for canning purposes.

On the positive side, the Ivanovo site director was the most enthusiastic and among the most appreciative of the Zaoksky greenhouse training course. As an Orthodox believer accustomed to meatless fasts, she was also the least troubled by the vegetarian meals in Zaoksky's Adventist cafeteria.

The Ivanovo site director's previous greenhouse experience proved valuable in such critical steps as growing and transplanting seedlings. In addition, this site director has been especially conscientious in teaching gardening skills to underprivileged youth, skills that can be a lifetime benefit to them. At the same time, this director recognizes the benefit of engaging orphan grads in constructive activity in the summer when many of them have free time.

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[112] "Ukraine Rapidly Increases Tomato Exports to EU," *Fruit-Inform*, 13 November 2015; Streljok, "IFC Initiative—Ukraine."
[113] Alexander Tsydendambaev, "An Overview of the Russian Industry," *A Greenhouse for Every Grower*, 24 January 2008.

Ivanovo is one of two sites that has given instruction in canning. In 2016 Ivanovo donated 30 three-liter (3.2 quarts) jars of preserved vegetables to a local orphanage. Young at-risk single mothers and orphan grads who helped in canning also received preserved vegetables for their personal use. Selyshche enjoyed an even greater return on its investment with foster children learning canning hands on: 110 liters (29.1 gallons) of cucumbers, 150 liters (39.6 gallons) of tomatoes, and 10 liters (2.6 gallons) of bottled tomato juice. Instruction in canning was not a requirement for site directors in exchange for donated greenhouses and greenhouse training, making this valuable outcome at Ivanovo and Selyshche all the more commendable. (Kozyatyn also preserved tomatoes for family use.)

A Summary of Practices to Avoid

1. Some site directors failed to maintain a consistently optimal greenhouse temperature. While 35˚ C (95˚F) should be the highest tolerated interior temperature, some sites registered much higher daytime figures: 50-53˚ C (122˚ - 127˚ F) at Potiivka and 42˚ C (108˚ F) at Bucha. To combat the heat the Min'kivtsi site director applied permanent white paint to the greenhouse roof, possibly reducing yield, rather than employing existing whitewash products that can be applied in the hottest part of the summer and removed with a soap solution when temperatures abate.
2. If cucumbers are picked while small, each plant can yield 35 to 50 cucumbers, whereas allowing fruit to grow bigger can reduce yield to 5 to 12 larger cucumbers, which are less desirable for both immediate consumption and canning.[114]
3. In some cases insufficient watering had a negative effect on yield. Most sites irrigated once per day, whereas twice a day would have been advantageous, as was the case at Kozyatyn. Unfortunately, the Min'kivtsi, Ukraine, site did not always water daily: with seven detrimental one-day gaps and two two-day gaps in watering.
4. Was the failure in some cases to maintain proper temperatures and to water at least daily a result of inadequate stress on these critical requirements in the Zaoksky training course? Or did site directors delegate these jobs to young helpers without sufficiently stressing their importance? Or did the press of other responsibilities come into play? Or did a less than ideal work ethic play a role? Some combination of affirmative answers to the above questions appears to be the case, depending upon the particular site in question.

As regards work ethic, it would appear to be on the decline in East and West. In the case of Russia, Dr. Chizov, director of the Zaoksky farm, shared the obvious: that “farming is hard work and is not so popular.”[115] Renowned American folk philosopher and environmentalist Wendell Berry notes the same general “contempt” for working the soil: “The discipline of farming has a low public standing….A farmer is popularly perceived as a ‘hick,’ without the dignity, knowledge, or social respectability” enjoyed by those employed in the professions. A farmer must contend with the stigma of surviving by means of what is perceived to be “a low form of drudgery.”[116] In the case of the former Soviet Union, anyone engaged in agriculture must endure the burden of its common association with the demeaning servitude of tsarist-era serfdom and Soviet-era collective farming.

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[114] Durham, *How Vegetable Gardening*, 34.
[115] Chizov to author, 10 September 2015.
[116] Wendell Berry, *The Unsettling of America: Culture and Agriculture* (Berkeley, CA: Counterpoint, 2015), ix-x.

Whatever the reasons, 2016 greenhouse site directors strayed from the recommendations of their Zaoksky training course almost as often as they followed them. As a result, the documented successes they enjoyed may have been due to the widely recognized advantages of protected greenhouse cultivation in general, more so than to the specifics of the Mittleider Method stressed in Zaoksky training. In the future, closer adherence to Mittleider recommendations might well produce an even greater harvest.

Parting Thoughts

United Methodist Church Bishop Hans Vaxby in his tenure in the former Soviet Union recognized that the congregations for which he was responsible had to take steps towards self-sufficiency if they were to survive long term.[117] To the extent that significant non-indigenous funding is in place, overcoming dependency is typically neglected or ignored, not just in the case of United Methodist churches and not just in Eurasia. The debilitating effects of dependency are almost universally the case as well for churches, parachurch ministries, and faith-based NGOs worldwide.

The Ukraine and Russia greenhouse project described in this report was undertaken to illustrate one approach to reducing reliance upon ministry funding from afar. The primary goal in distributing this report in Russian and in English is to encourage its readers to recognize that successful greenhouse cultivation is quite feasible even in cases of a relatively small investment—as long as growers possess a healthy work ethic.

[117] Vaxby, “Striving for Congregational Self-Sufficiency”, 1-3.

Acknowledgements

The present report rests upon many shoulders. I have been the grateful recipient of contributions from many specialists. As for agricultural consultants, critical advice and counsel came from Dr. Alexei Chizov, director of the Zaoksky farm near Tula, Russia; James Kennard, president of the Food for Everyone Foundation; Scott McKenzie of Grow Appalachia, Berea College, Berea, Kentucky; and four professors of horticulture from the University of Kentucky College of Agriculture: Dr. Ray Smith, Dr. Brent Rowell, Dr. Tim Woods, and Dr. Shubin Saha (now employed by Kentucky Fresh Harvest).

I also am greatly indebted to Sergiy Dzyba, Kyiv-based Ukraine greenhouse project coordinator, and his wife, Irina Dzyba, who prepared seedlings for all five Ukraine greenhouse sites. Thanks are also due to Jenya Polonskaya Haps, vice-president of Orphan's Tree, who monitored developments at the Ivanovo, Russia, site; Alison Giblett, Genesis Project, Kyiv, who recruited several Ukraine greenhouse site directors and who assisted in securing essential labor and yield statistics; and Dr. Orest Holovaty, who provided helpful critiques of several drafts of the report.

The hard work of site directors was obviously vital to the success of the project: Dmytro Dukhin (Bucha), Maksim Shestakov (Kozyatyn), Vitalii Hrybivskii and Aleksandr Prynyk (Min'kivtsi), Roman Maistruk (Potiivka), Serhii Yurchuk (Selyshche), and Tatyana Kiselyova (Ivanovo). In addition, a diligent Joy Ireland cheerfully typed multiple drafts of the report, and Jerry Diddle solved many technical issues over many months. Beth Gardner, Darlene Elliott, and Billie Faye Harvey proved invaluable as editors and proofreaders, while Ekaterina Vatulya ably translated the English text and appendices into Russian. Finally, ten donors provided funding without whom the greenhouse project could not have been undertaken.

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Appendix I

Dependency, a Longstanding Dilemma

Wrestling with how best to foster self-sustaining churches and ministries is not an issue unique to the post-Soviet context. Rather, extended substantive reflection on how best to overcome dependency in missions has been addressed for over a century and a half by a host of mission practitioners, administrators, and historians. Taking into account their observations helped shape my own thinking and planning for the 2016 Ukraine and Russia greenhouse project. Especially compelling were the writings of Henry Venn (1796-1873), head of the Anglican Church Missionary Society, 1841-1872; Rufus Anderson (1796-1880), Congregational Church member and head of the American Board of Commissioners of Foreign Missions, 1832-1866; John Nevius (1829-1893), American Presbyterian missionary to China and Korea; Roland Allen (1864-1947), Anglican missionary to China and Kenya and author of two mission classics: *Missionary Methods: St. Paul's or Ours?* (1912) and *The Spontaneous Expansion of the Church and the Cause Which Hinders It* (1927); Bishop Stephen Neill (1900-1984), Anglican missionary to India and mission historian; and Lesslie Newbigen (1909-1998), Anglican missionary to India and global Christian statesman.

More recently, Steve Corbett and Brian Fikkert, U.S. Covenant College professors, have authored *When Helping Hurts: How to Alleviate Poverty without Hurting the Poor…and Yourself*, 2nd ed. (Chicago: Moody Press, 2012). In the same vein, Robert Lupton, Atlanta, Georgia, urban Christian activist, has published *Toxic Charity: How Churches and Charities Hurt Those They Help* (New York: HarperCollins, 2011) and *Charity Detox: What Charity Would Look Like If We Cared about Results* (New York: Harper One, 2016).

Appendix II
Greenhouse Garden Records Journal
(Please print clearly.)

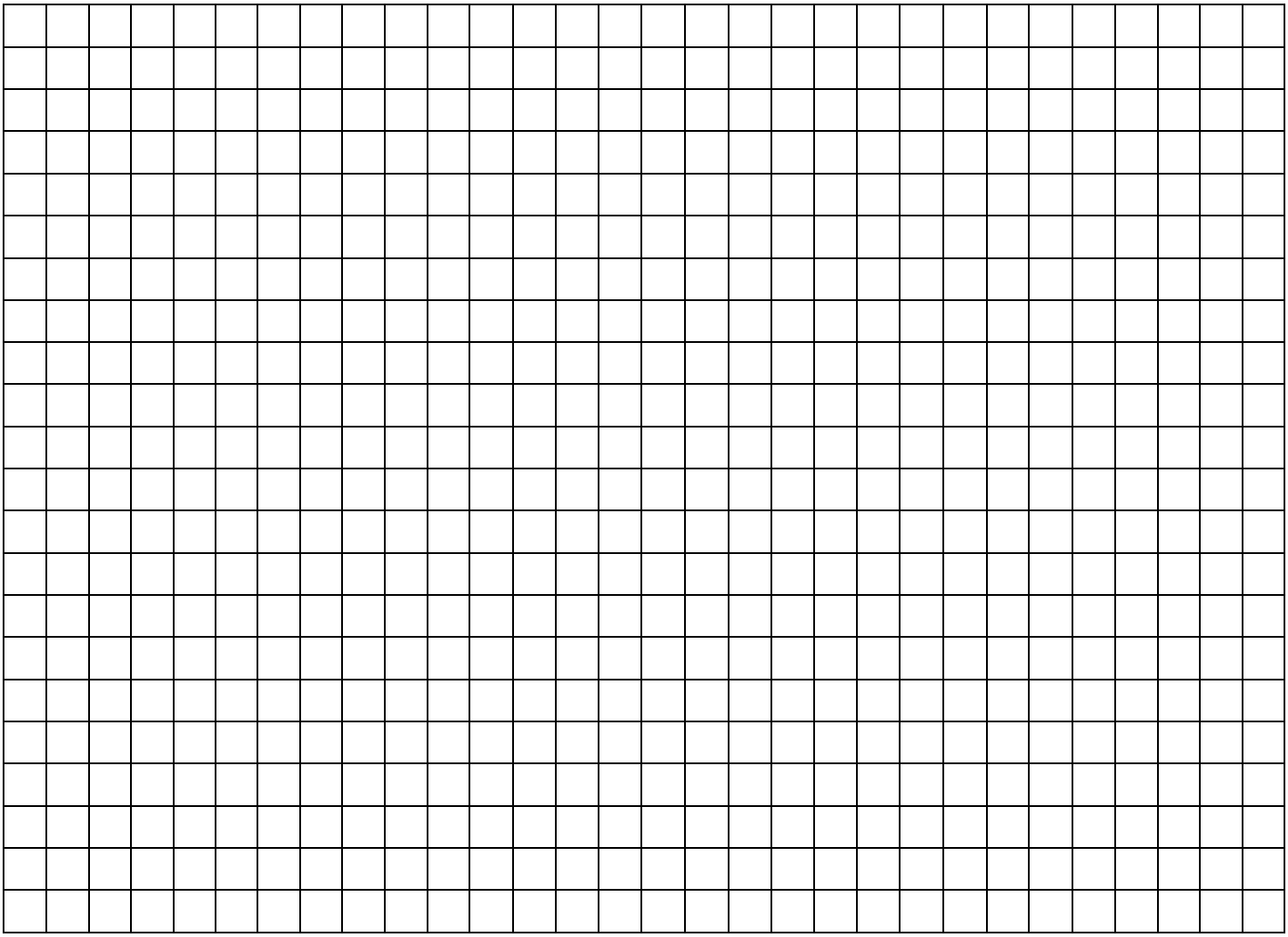
Contact Person(s): _____

Location (Address): _____

Phone and Email: _____

Latitude: _____

Garden Plot Graph
Use the grid area below to graph out your garden for appropriate size and spacing.
Each square equals approximately .2 meter (7.9 inches)
(north)

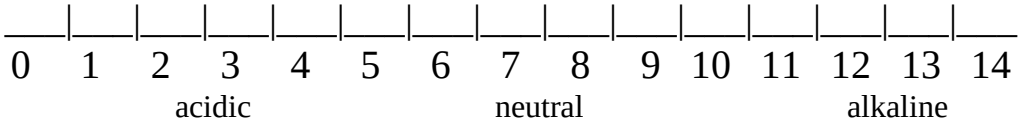


entrance (south)

Soil Preparation

It is important to determine the PH level in the soil. Take a soil sample to the Zaoksky training course for testing.

Graph PH Balance



Composition of Soil: percentage of clay ____, sand ____, and silt ____

Soil supplements used:

Peat moss ___yes ___no; amount ____; cost ____

Sand ___yes ___no; amount ____; cost ____

Fertilizer* ___yes ___no; amount ____; cost ____

Manure ___yes ___no; amount ____; cost ____

Compost**___yes___no; amount___; cost____

Lime ___yes ___no; amount ____; cost ____

*Types of fertilizers: _____

_____

**In growing seedlings for transplanting, use sterilized compost or commercially purchased potting soil to avoid seedling disease problems.

Onsite Daily Work Checklist

Make multiple copies of this checklist for use at the greenhouse and then later transfer the times to the "Daily Garden Work Calendar" in this Greenhouse Garden Records Journal. This form is designed for the use of up to three workers per day.

Minutes per day and type of work _____date	Minutes per day and type of work _____date	Minutes per day and type of work _____date
1_____soil preparation	1_____soil preparation	1_____soil preparation
2_____ working with seedlings	2_____ working with seedlings	2_____ working with seedlings
3_____ transplanting	3_____ transplanting	3_____ transplanting
4_____ pruning	4_____ pruning	4_____ pruning
5_____ watering	5_____ watering	5_____ watering
6_____ weeding	6_____ weeding	6_____ weeding
7_____ pest and disease control	7_____ pest and disease control	7_____ pest and disease control
8_____ greenhouse maintenance	8_____ greenhouse maintenance	8_____ greenhouse maintenance
9_____ ventilating	9_____ ventilating	9_____ ventilating
10_____ harvesting	10_____ harvesting	10_____ harvesting
_____worker initials	_____worker initials	_____worker initials

A sample entry from this checklist transferred to a particular date block in the Greenhouse Garden Records Journal might read: 4-15; 5-25; 6-20; 9-15 which would mean 15 minutes devoted to pruning (4); 25 minutes watering (5); 20 minutes weeding (6); and 15 minutes ventilating (9), for a total of one hour and 15 minutes work on this day.

The assumption with each entry will be that work cultivating tomatoes and cucumbers is roughly equal. If on occasion there is a significant difference between time worked on one or the other, the time difference is to be shown with a slash mark between minutes spent on tomatoes and minutes spent on cucumbers. For example, 6-5/15 would mean weeding (6) involved 5 minutes on tomatoes and 15 minutes on cucumbers on a particular day.

Daily Garden Work Calendar

Calculate time per day devoted to 1) soil preparation, 2) working with seedlings, 3) transplanting, 4) pruning, 5) watering, 6) weeding, 7) pest and disease control, 8) greenhouse maintenance, 9) ventilating, and 10) harvesting.

Month: April **Year:** 201_

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

[Daily Garden Work Calendars for May-December 2016 omitted.]

Individual Plant Profile

[Prepare a sheet for each plant type cultivated in the greenhouse.]

Plant name _____and variety_____

Date seeds planted_____and seed depth in soil_____

Date of last frost_____

Date seedlings transplanted _____

Average height of transplanted seedlings _____

Total number transplanted_____

Plant spacing _____and number of plants per row_____

Row spacing _____

Average amount of water per week_____

Total amount of fertilizer_____ and manure_____used

Dates and amounts of weekly fertilizer applications from planting to harvesting

_____

_____

Pest problems (types of pests and degree of damage: ___ mild ___ moderate ___ severe)

_____

_____

Disease problems (types of diseases and degree of damage: ___ mild ___ moderate ___ severe)

_____

_____

Dates, names of, and amounts of pest and disease control applications and levels of success (excellent, moderate, or poor) for each type of control used:

_____

_____

Beginning harvest date _____ and last harvest date _____

Total amount_____and purchase cost_____of fertilizer for this plant

Total amount_____and purchase cost (if any)_____of manure for this plant

Total yield of this plant by weight_____

Quantity _____and percentage_____of yield consumed

Quantity____ and percentage ____sold; and gross income_____from sale

Overview

What worked well in growing tomatoes?: _____
_____
_____

What were the major challenges in growing tomatoes?: _____
_____
_____

What worked well in growing cucumbers?: _____
_____
_____
_____

What were the major challenges in growing cucumbers?: _____
_____
_____

Total Yield and Value of Harvest

In growing tomatoes:

What was the total yield by weight?: _____

What was the total number of hours worked?*****: _____

What was the amount of labor per kilo of yield?: _____

What was the amount (by weight) of tomatoes consumed or donated?: _____

What was the amount (by weight) of tomatoes sold?: _____

What was the total gross income from tomatoes sold?: _____

_____

In growing cucumbers:

What was the total yield by weight?: _____

What was the total number of hours worked?*****: _____

What was the amount of labor per kilo of yield?: _____

What was the amount (by weight) of cucumbers consumed or donated?: _____

What was the amount (by weight) of cucumbers sold?: _____

What was the total gross income from tomatoes sold?: _____

_____

What was the total gross income from sales of tomatoes and cucumbers?: _____

_____

*Including soil preparation, working with seedlings, transplanting, pruning, watering, weeding, pest and disease control, ventilation, greenhouse maintenance, and harvesting, *but not greenhouse construction*.

Appendix III

Monthly Work Calculations

Categories of Labor: Total Time in Minutes/Hours Per Month

Bucha	April	May	June	July	August	September	October	Labor Category Totals
Labor Categories								
1. soil preparation	0	390	60	0	120	20	0	590
2. working with seedlings	0	420	140	0	0	0	0	560
3. transplanting	0	0	0	0	240	0	0	240
4. pruning	0	300	575	90	765	105	270	2,105
5. watering	0	240	420	450	435	330	75	1,950
6. weeding	0	120	345	310	130	90	60	1,055
7. pest/disease control	0	0	0	60	0	0	180	240
8. greenhouse maintenance	0	0	0	0	0	0	120	120
9. ventilating	0	265	450	465	465	330	90	2,065
10. harvesting	0	0	50	112	400	132	26	720
Total minutes/hours per month	0	1,735/28.9	2,040/34	1,487/24.8	2,555/42.6	1,007/16.8	821/13.9	9,645/ 161 hrs.

Categories of Labor: Total Time in Minutes/Hours Per Month

Kozyatyn	April	May	June	July	August	September	October	Labor Category Totals
Labor Categories								
1. soil preparation	240	0	0	0	0	0	0	240
2. working with seedlings	0	294	205	0	0	0	0	499
3. transplanting	0	80	0	0	0	0	0	80
4. pruning	0	0	485	150	120	0	0	755
5. watering	0	315	455	470	505	295	140	2,180
6. weeding	0	0	20	0	0	0	0	20
7. pest/disease control	0	0	15	30	180	0	0	225
8. greenhouse maintenance	0	180	120	40	0	0	0	340
9. ventilating	0	30	60	60	62	44	6	262
10. harvesting	0	0	215	1,508	855	155	120	2,853
Total minutes /hours per month	240/4	899/15	1,575/26.3	2,258/37.6	1,722/28.7	494/9.2	266/4.4	7,454/ 125.2 hrs.

Categories of Labor: Total Time in Minutes/Hours Per Month

Min'kivtsi	April	May	June	July	August	September	October	Labor Category Totals
Labor Categories								
1. soil preparation	120	0	0	0	0	0	0	120
2. working with seedlings	0	40	190	0	30	15	40	315
3. transplanting	0	0	0	0	0	0	0	0
4. pruning	0	0	65	80	40	0	0	185
5. watering	0	220	515	600	620	380	140	2,475
6. weeding	0	0	60	0	0	0	0	60
7. pest/disease control	0	0	60	75	110	0	0	245
8. greenhouse maintenance	0	0	0	0	0	0	0	0
9. ventilating	0	198	450	450	465	405	170	2,138
10. harvesting	0	0	200	260	260	120	60	900
Total minutes /hours per month	120/2	458/7.6	1,540/25.7	1,465/24.4	1,525/25.4	920/15.3	410/6.8	6,438/ 107.2 hrs.

Categories of Labor: Total Time in Minutes/Hours Per Month

Potiivka	April	May	June	July	August	September	October	Labor Category Totals
Labor Categories								
1. soil preparation	0	0	0	0	0	0	0	0
2. working with seedlings	0	40	110	0	0	0	0	150
3. transplanting	0	90	0	0	0	0	0	90
4. pruning	0	25	260	150	80	0	0	515
5. watering	0	280	435	455	495	410	90	2,165
6. weeding	0	0	30	0	0	0	0	30
7. pest/disease control	0	0	60	45	90	0	0	195
8. greenhouse maintenance	0	0	0	0	0	0	0	0
9. ventilating	0	270	450	450	465	335	115	2,085
10. harvesting	0	0	235	785	555	150	125	1,850
Total minutes /hours per month	0	705/11.8	1,580/26.3	1,885/31.4	1,685/28.1	895/14.9	330/5.5	7,080 /118 hrs.

Categories of Labor: Total Time in Minutes/Hours Per Month

Location: Selyshche	April	May	June	July	August	September	October	Labor Category Totals
Labor Categories								
1. soil preparation	0	0	0	0	0	0	0	0
2. working with seedlings	0	0	100	105	0	30	120	355
3. transplanting	0	270	0	0	0	0	0	270
4. pruning	0	0	0	0	330	30	0	360
5. watering	0	220	230	220	525	205	40	1,440
6. weeding	0	0	340	100	0	0	0	440
7. pest/disease control	0	50	75	0	0	125	0	250
8. greenhouse maintenance	0	0	0	0	0	0	0	0
9. ventilating	0	90	300	250	280	160	170	1,250
10. harvesting	0	0	0	40	495	220	320	1,075
Total minutes/ hours per month	0	630/10.5	1,045/17.4	715/11.9	1,630/27.2	770/12.8	650/10.8	5,440/ 90.7 hrs.

Categories of Labor: Total Time in Minutes/Hours Per Month

Location: Ivanovo	April	May	June	July	August	September	October	Labor Category Totals
Labor Categories								
1. soil preparation	0	0	280	0	0	0	0	280
2. working with seedlings	700	1,120	340	0	0	0	0	2,160
3. transplanting	0	0	80	0	0	0	0	80
4. pruning	0	0	45	250	110	0	0	405
5. watering (by hand)	0	0	260	1,350	300	0	0	1,910
6. weeding	0	0	20	30	0	0	0	50
7. pest/disease control	0	0	0	80	0	0	0	80
8. greenhouse maintenance	0	0	0	0	0	0	0	0
9. ventilating	0	0	355	435	210	0	0	1,000
10. harvesting	0	0	0	30	180	0	0	210
11. fertilizing	0	0	50	85	30	0	0	165
12. staking	0	0	160	440	0	0	0	600
Total minutes/hours per month	700/11.7	1,120/18.7	1,590/26.5	2,700/45	830/13.8	0	0	6,940/ 115.7 hrs.

Appendix IV

Categories of Labor: Total Time Per Site in Minutes/Hours and (Percentage) of Total Labor

	Bucha		Kozyatyn		Min'kivtsi		Potiivka		Selyshche		Ivanovo	
Labor Categories												
1. soil preparation	590	(6.2)	240	(3.2)	120	(1.9)	0	(0.0)	0	(0.0)	280	
2. working with seedlings	560	(5.8)	499	(6.7)	315	(4.9)	150	(2.1)	355	(6.5)	2,160	(31.1)*
3. transplanting	240	(2.5)	80	(1.1)	0	(0.0)	90	(1.3)	270	(5.0)	80	(1.2)
4. pruning	2,105	(21.8)	755	(10.1)	185	(2.9)	515	(7.3)	360	(6.6)	405	(5.8)
5. watering	1,950	(20.2)	2,180	(29.2)	2,475	(38.4)	2,165	(30.6)	1,440	(26.5)	1,910	(27.5)
6. weeding	1,055	(10.9)	20	(0.3)	60	(0.9)	30	(0.4)	440	(8.1)	50	(0.7)
7. pest & disease control	240	(2.5)	225	(3.0)	245	(3.8)	195	(2.8)	250	(4.6)	80	(1.2)
8. greenhouse maintenance	120	(1.2)	340	(4.6)	0	(0.0)	0	(0.0)	0	(0.0)	0	(0.0)
9. ventilating	2,065	(21.4)	262	(3.5)	2,138	(33.2)	2,085	(29.4)	1,250	(23.0)	1,000	(14.4)
10. harvesting	720	(7.5)	2,853	(38.3)	900	(14.0)	1,850	(26.1)	1,075	(19.7)	210	(3.0)
11. fertilizing**											165	(2.4)
12. staking**											600	(8.7)
Grand Total	9,645 /160.8		7,454/124.2		6,438/107.3		7,080/118		5,440/90.7		6,940/115.7 hrs.	

*Ivanovo, Russia, prepared its own seedlings, whereas Irina Dzyba prepared seedlings for all Ukraine sites.

**It is assumed that Ukraine sites included time spent on fertilizing and plant staking under other labor categories.

Appendix V

Greenhouse Tomatoes Cultivation Data

	Ukraine					Russia	Average of all sites
	Bucha	Kozyatyn	Min'kivtsi	Potiivka	Selyshche	Ivanovo	
Average height of seedlings (inches)	5.9	8.9	8.9	8.9	8.9	15.5	9.4
Number of seedlings	50	60	60	70	60	65	61
Average plant spacing (inches)	7.9	7.9	7.9	7.9	11.8	9.8	8.9
Spacing between rows (inches)	35.4	27.6	25.6	25.6	23.6	35.4	28.9
Average water per week (gallons)	63.4	115.4	219.8	131.9	175.8	49.5*	126
Total amount of fertilizer (pounds)	95.2	35.7	52.9	35.7	7.9 (manure)	2.9	20.6
Total cost of fertilizer per site	666 hryvnia	666 hryvnia	286.2 hryvnia	666 hryvnia	666 hryvnia	1,500 rubles	590 hryvnia**
Average yield per plant (pounds)	18.3	9.2	7.7	12.3	8.8	5.1	10.2

Greenhouse Cucumbers Cultivation Data

	Ukraine					Russia	Average of all sites
	Bucha	Kozyatyn	Min'kivtsi	Potiivka	Selyshche	Ivanovo	
Average height of seedlings (inches)	5.9	8.9	8.9	8.9	8.9	2.4	7.3
Number of seedlings	50	30	50	45	60	55	48
Average plant spacing (inches)	7.9	7.9	7.9	7.9	11.8	9.8	8.9
Spacing between rows (inches)	35.4	27.6	25.6	25.6	23.6	35.4	28.9
Average water per week (gallons)	63.4	115.4	219.8	131.9	175.8	93.4*	163
Total amount of fertilizer (pounds)	47.6	17.9	26.5	17.9	4 (manure)	3	19.5
Total cost of fertilizer per site	333 hryvnia	333 hryvnia	143.1 hryvnia	333 hryvnia	333 hryvnia	1,500 rubles	295 hryvnia**
Average yield per plant (pounds)	14.3	60.3	14.6	11.8	15.4	4.8	20.2

*Based on the belief that cucumbers require more water than tomatoes, the Ivanovo site utilized nearly double the water in its cucumber greenhouse compared to its tomato greenhouse.

**Average cost of fertilizer per Ukrainian site (March 2016)

Appendix VI

Tomatoes and Cucumbers: Labor and Yield

Location	Total yield by weight in pounds	Total number of hours worked on tomatoes & cucumbers	Minutes of labor per pound of yield	Pounds of tomatoes & cucumbers consumed or donated	Pounds of tomatoes & cucumbers sold	Gross income from tomatoes & cucumbers sold
Bucha	1,634	161	5.9	1,634	0	0
Kozyatyn	2,359	124	3.2	1,918	441	1,400 hryvnia
Min'kivtsi	1,197	107	5.4	1,197	0	0
Potiivka	1,378	118	5.1	1,378	0	0
Selyshche	1,455	91	3.7	1,455	0	0
Ivanovo	331	116	21	331	0	0

Appendix VII

Yield Per Labor Unit Calculations

Location	Total yield in pounds					Total labor in minutes (hours)	Minutes of labor per pound of yield
	Cucumbers	+	Tomatoes	=	Total		
Bucha	718.7	+	914.9	=	1,633.6	9,645 (160.8)	5.9
Kozyatyn	1,807.8	+	551.2	=	2,359	7,454 (124.2)	3.2
Min’kivtsi	734.1	+	463	=	1,197.1	6,438 (107.3)	5.4
Potiivka	529.1	+	860	=	1,389.1	7,080 (118)	5.1
Selyshche	925.9	+	529.1	=	1,455	5,440 (90.7)	3.7
Ivanovo	264.5	+	66.1	=	330.6	6,940 (115.7)	21