Rooftop Farming Tool Kit

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Background

During this rapidly changing world, people are looking for more and more places to grow crops. With the growing awareness of climate change, communities are coming together to create farms that are both environmentally and economically conservative, while being able to feed people in urban areas. Rooftop farming provides that space people need, which would otherwise go unacknowledged, to cultivate fruits and vegetables in areas that are seemingly impossible. This tool kit is a basic instruction manual, served to help both experts and non-experts build a green rooftop space, while taking costs into consideration.

Preparing a Rooftop

As exciting as a rooftop garden sounds, preparing a rooftop garden is a vital step in ensuring a productive garden. There are a number of factors to keep in mind when starting your rooftop, which include but are not limited to budget, climate, microclimate, sun exposure, and rooftop design and structure. This manual will cover essential preparation elements designed specifically for Seattle rooftops.

Assessing Climate

It is important to examine both short-term and long-term conditions of the garden environment. In short, assessing both the weather and climate are essential because it will determine if a certain gardening system can be suited with the environment. Below is a chart as a quick-start guide to assess your climate.

Temperature	Typically the highest and lowest mean temperature. Critical in assessing what plants will thrive in your environment.
Frost and Freeze Dates	An average of the last day in spring where temperature drops below freezing and the first day of fall where the temperature drops below freezing again. A great guide for gardeners to plant seeds in the spring and to count down days until crops will be damaged in the fall due to frost.
Growing Season	The length of growing season is the number of days between frost-free and frost dates. This is important in assessing which plants are best suited for your garden environment.
Mean Precipitation	This is the average monthly rain and/or snowfall in inches. The average indicates what crops and irrigation systems work well in your area.
Extreme Precipitation	Data of extreme rain/snow in the month of year given in inches. Extreme precipitation can lead to above-normal snow or rain levels.

Assessing Microclimate

Microclimate refers to the climate of your rooftop and gardening space, which differs from the climate surrounding it. It is important to assess your microclimate because the temperature, moisture, and wind differs to that of the climate, in general. For example, a rooftop garden's microclimate differs from that of a ground-level garden. Below is a chart of common rooftop microclimates to keep in mind when preparing your rooftop.

Shadow Projections	Evaluate shade projections by nearby buildings, trees, etc. This will factor into sun exposure on the roof. Crisp shadow = Full sun Diffuse shadow = Bright shade Hazy shadow = Medium shade No shadow= Deep shade
Damp Zones	Analyze any areas of the roof where there is a slop or poor drainage after rainfall. You can tell when ponding occurs.
Wind Zones	Assess wind force and direction. The higher up your rooftop, the harsher the wind.
Hot Spots	Heat islands can affect your roof as temperatures on hot rooftops can rise. This can be caused due to reflective surfaces, heat-trapping materials, heat generated by cars, buildings, etc. Heat generated from heat-trapping air pollutants also contributes to the heat island effect.

ASSESSING YOUR ROOFTOP

- Do you have water access?
- Where and how is your roof's drainage?
- What is the condition of the roof's membrane?
- Do you know your building codes? Zoning and health regulations?
- What is the roof's weight-bearing load capacity?
- Is it construction and installation accessible?
- What permits need to be acquired?
- What other spaces need to be planned out? Example: compost, storage
- Are any repairs needed to be made before starting your rooftop garden?

Farming Methods
In-Ground Beds

(Recommended for beginners and experts)

In-ground beds is a farming method that requires growing directly on the ground.

Positives	Negatives
- In-ground beds are great for areas that already have existing soil. - They require less water than raised beds due to the decrease in drainage. - It is easier to install an irrigation system since it is flat on the ground. - If needed, can change the bed shape to be more suitable for needs.	- Leads to compact soil due to foot traffic. - Is not neat; the soil can spread across the rooftop. - Wastes more soil due to the pathways created to walk between plants. - Difficult to manage for smaller spaces.

Steps to Consider

1. Weight Constraints	2. Proper Drainage	3. Space Management
Many rooftops are not well suited for the heavy weight of soil. Make sure to know the maximum weight allowed on each infrastructure.	In-ground gardens can get messy; a good drainage layer can prevent soil from getting into gutters and rainwater from drowning the plants.	Make sure to divide the beds so there is space in between. This will allow people to work effectively in the garden.

Raised Beds

(Recommended for beginners and experts)

Raised bed gardens enclose the plants and soil above the surrounding environment.

Positives	Negatives
- Manageable way to garden a smaller space more intensively. - Protection against foot traffic. - Since raised beds drain better, they will warm up more quickly in the spring. - For those who have a hard time bending over, raised beds can offer extra support with its greater height.	- Raised bed containers could potentially become damaged over time. - More expensive in initial costs to build the container for raised bed.

Square foot gardening: Gardening technique used for raised beds where plants are cultivated close together to maximize space.

How to Create Square Foot Gardens?

Create a garden bed and then divide the space into 1-foot squares. Place seeds in each one of the squares.

Positives	Negatives
- Great for farmers who are using a smaller space. - More harvest for a variety of plants per square footage. - Supports polyculture	- Not sufficient for plants that need a lot of room.

Wood Options For Raised Beds

Redwood	Cedar	Douglas Fir
Lasts up to 20 years	Lasts 10-15 years	Lasts 5-7 years

Building a Raised Bed

Materials Needed
- Wooden Boards - 3 ½ inch Deck Screws - Cordless Drill    

Steps

1. Make sure to measure out the wooden boards, so the sides are even.
2. Mark where you are going to build the raised bed.
3. Once the land is marked, make sure the ground is leveled.
4. Fasten the boards at the corners by screwing them together.
5. Check to see if everything is even and stable.

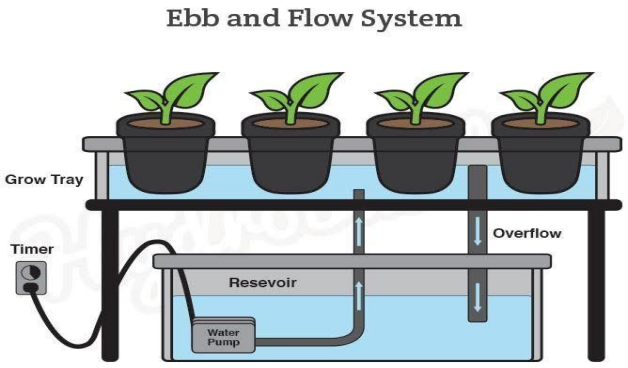
Alternative Materials

Untreated Wood	- Can last up to three or more years. - They break down faster than other options.
Rock	- Can use rocks around the backyard as a border for the raised bed. - The cheapest and simplest option, unless one buys store bought rocks.
Brick and Cement Rock	- Both brick and cement rock will last a long time once built. - Although cement rock is cheaper than brick, older options can contain metals that can contaminate the garden.

Hydroponics

(Not recommended for beginners)

Method of growing plants without soil, substituted with mineral nutrient solutions in a water solvent and inert medium.



Two types of systems to consider:

- **Active:** involves the use of a water pump and moves the water to the root zone.
- **Passive:** water does not need to be transported to the plants (deep water culture).

Materials needed:

- Reservoir (holds water + supplies nutrients to plants)
- Water pump (to supply plants with water)
- Water filters
- Timer (to assist regulation in watering, ventilation and lighting cycles)
- Lighting (to enhance growth)
- Inert medium (to physically support plant growth- provides no nutritional value)
- pH test kit (to maintain healthy pH balance of nutrient solution)
- Air pumps
- Nutrient solution
- Plant(s)

Important notes:

- Cleaning reservoirs often
- Growing temperature is best between 70-75F
- Ventilation is important to avoid fungal infections

System	Summary	Positives	Negatives
Deep Water Culture (DWC) (easiest to use)	- Plants are suspended in a reservoir with nutrient solution. - Constant supply of nutrients to the roots.	- Simple. - Low maintenance. - User friendly.	- Easy to overfeed plants. - No buffer to protect plants from overfeeding. - Requires air pump and stone for oxygen flow. Pricey.
Hydroponic Drip Systems	- Plants are fed from the top instead of directly at the roots. - Drippers slowly feed the plants.	- Easy to control feedings. -Cost efficient.	- Prone to nozzles clogging if not using organic nutrients.
Aeroponics	- Plants are suspended in the air instead of water like the DWC system. - Sprayers emit a mist of nutrients and water directly to the root zone of the plant.	- Does not require air pumps. - Good for growing numerous small plants. -Small system.	- Geared towards professional growers. - Needs specific nozzles per plant. - Relies on electricity because of timer.
Ebb and Flow Systems (ideal for smaller budgets)	- Roots are suspended in a nutrient solution that is dispersed periodically. - Roots are submerged for a period then drained.	- Saves water and nutrients by reusing. -Takes up less space than DWC.	- Constantly needs to be refilled with new solution after being diluted too far. - Difficult to set up.

Types of inert mediums:

Perlite	- Volcanic glass that is heated and expanded, creating small pebbles with pockets inside of them. - Great if there is plenty of water touching roots already.
Rockwool (tricky to use)	- Wool that is made out of rocks. - Retains water but dries out quickly. - Commonly used in addition with perlite or clay pebbles. - Common mistake: over/under watering plants due to water retention.
Clay pellets/pebbles (most popular)	- Pebble shape allows water to reach roots easily. - Space between pebbles allows for roots to grow freely.
Vermiculite (similar to perlite)	- Heated and expanded rocks. - Retains water better than perlite. - Commonly used with perlite to avoid drowning plants.

Positives	Negatives
- No soil-borne pests due to the absence of soil. - The nutrients plants are receiving will be directly coming from what is fed to them at the root zone therefore reduction in nutrient leaching. - Water efficient. Water can also be reused. - 25% faster growth rate than traditional soil growing. - 30% increase in yields. - Less carbon footprint. No need for plowing, seeding, weeding, fertilization and cultivation. - Growing year round. - More personal space.	- Learning curve. Difficult to get started with little room for error. Not recommended for first time growers. - Requires reliable management and supervision. - Expensive. Systems are pricey to purchase. - Waterborne diseases. - Equipment failure.

Container Gardening

(Great for beginners)



Method of growing within a portable enclosed container (horizontal or circular).

Materials needed:

- Container with a drainage system (holes at the bottom and saucer)
- Potting mix
- Fertilizer
- Plants

Types of pots:

Clay pots	- Retains warmth but may cause plants to dry out faster. - More attractive than black pots. - Heavy. - Can break.
Plastic pots	- Retains moisture well. - Cheap. - Lightweight.
Hanging pots/baskets	- Great for space. - Herbs, cherry tomatoes, and strawberries.
Colored pots	- Lighter pots reflect light and keep things cooler and more moist. - Darker colors absorb and hold heat so plants dry out more quickly.

*The temperature of the pot will affect how often plants need water and nutrients.

Positives	Negatives
- Convenient due to their portability and accessibility. - Can be visually appealing. - Minimal time commitment.	- Pots dry out faster, sometimes requiring waterings twice a day. - More fertilizer needs. - Requires soil and growing mediums depending on plants. - Containers can be expensive. - Heavy. - Plants outgrow containers. - Pests.

Plants

Washington Grown Vegetable Seasonality Chart

by Healthier US School Challenge Vegetable Group

categories	produce	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Green	Arugula												
	Beet green												
	Bok Choy, baby												
	Broccoli												
	Braising Mix												
	Chards												
	Collard greens												
	Dandelion greens												
	Endive, Curly (Fresee)												
	Escarole												
	Kales									**	**	**	
	Kohlrabi greens												
	Lettuces, leaf												
	Lettuces, butter												
	Lettuces, Romaine												
	Mustard greens												
	Mizuna												
	Rapini (Broccoli Rabe/Chinese broccoli)												
	Salad mix (Mesclun*)												
	Spinach												
	Turnip greens												
	Watercress												
Orange	Carrots						**	**	**	**	**		
	Pumpkins												
	Sweet potatoes (yams)									**	**	**	
	Winter squash, Acorn										**	**	**
	Winter squash, Butternut										**	**	**
	Winter squash, Hubbard										**	**	**
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Starchy	Corn/Sweet Corn												
	Green peas/shell peas												
	Green peas, snap/snow												
	Potatoes												
	Sunchokes (Jerusalem artichoke)												
Other	Asparagus												
	Artichokes												
	Beets					‡	‡	‡	‡	‡			
	Brussels sprouts												
	Cabbages, green												
	Cabbages, red												
	Cabbages, savoy												
	Cabbages, napa												
	Cauliflower & Romanesco												
	Celery												
	Celery root (Celeriac)												
	Cucumbers												
	Fennel												
	Green beans												
	Kohlrabi, root												
	Leeks												
	Lettuce, Iceburg												
	Onions, yellow/storage												
	Onions, sweet												
	Parsnips												
	Pea vines												
	Peppers												
	Radicchio (Chicory, red-leaved)												
	Radishes												
	Rhubarb												
	Summer squash, white scallop												
	Summer squash, yellow												
	Summer squash, zucchini												
	Tomatillos												
	Tomatoes												
	Turnips, root												

* Mesclun often includes arugula, chervil, leafy lettuces, endives and other greens such as mizuna, radicchio or sorrel.

** Peak harvest season for this product. However, this product is stored and available in other seasons from local sources.

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Sources include: Washington Agricultural Commodity Commissions; WSDA From the Heart of Washington, Puget Sound Fresh, WSDA Farm-to-School survey responses; Full Circle Farm; Tonnemaker Family Orchard

Washington Grown Fruits, Legume and Herbs Seasonality Chart

categories	produce	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Vitamin A	Apricots												
	Cantaloupe												
	Nectarines												
	Peaches, yellow												
	Plums, purple												
Vitamin C	Blackberries												
	Blueberries												
	Cantaloupe												
	Honeydew melon												
	Raspberries												
	Strawberries												
Other	Apples									*	*	*	
	Asian pears												
	Cherries, Bings												
	Cherries, Rainiers												
	Currants												
	Grapes												
	Pears									*	*	*	
	Pluots												
	Quince												
	Watermelons												
	Frozen berries												
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Legume	Black beans, dry												
	Cranberry beans, dry												
	Garbanzo/Chickpea, dry												
	Great Northern beans, dry												
	Kidney beans, dry												
	Lentils, dry												
	Navy beans, dry												
	Pink beans, dry												
	Pinto beans, dry												
Herbs	Basil												
	Chives												
	Cilantro/Coriander												
	Dill												
	Fennel												
	Lavender												
	Garlic												
	Mint												
	Oregano												
	Parsley												
	Rosemary												
	Sage												

* Peak harvest season for this product. However, this product is stored and available in other seasons from local sources.

Sources include: Washington State Department of Agriculture (WSDA); Washington Agricultural Commodity Commissions; WSDA From the Heart of Washington, Puget Sound Fresh, WSDA Farm-to-School survey resoponses; Full Circle Farm; Tonnemaker Family Orchard

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Financial Costs of Crops

- Most crops only cost a few dollars for a packet of seeds
- Generally, it is cheaper to grow crops rather than to purchase at the store
    - Example: A tomato plant costs around $4 which produces 8lb, it would cost $2.56/lb at the store

- Example: Zucchini and summer squash costs $3 per packet of seeds, producing 6-10lb, where it would cost $9.84-$16.30 at the store

Succession-Planting

Some crops can be planted consecutively during the growing season. Typically, one will plant a crop such as peas, and after a couple weeks one will replace peas with carrots.

Two-Week Succession Planting

*This table illustrates the order to grow and replace crops

Plants to Pull Up	**Plants to Replace With**
Peas	Carrots
Broccoli	Salad Greens
Spinach	Collard Greens
Lettuce	Radishes
Tomatoes	Garlic
Beets	Kale
Salad Greens	Leeks

Foundations for Growing Plants

Lifespan of farming methods to consider (on roofs):

- Range for conventional roof farming is $7.50 sq. ft.
    - Lifespan = 15 years
- Range for green roof farming is $25 sq. ft
    - Lifespan = 3-4x compared to conventional

Each farming method accommodates different obstacles, but for those who want to begin planting should consider these few factors when choosing plants

- How many #plants can be grown in one row for a vegetable, fruit, legume, etc.?
- What is the production per row for the plant?
- How much space does each plant need to grow properly
- Are there differences in home-grown plants vs. store-bought? Which should you avoid?

Table 3. Average home-grown vegetable productivity and consumption for crops commonly grown in Washington (adapted from Antonelli et al. 2004, 5).

Vegetable	Plants per 10-ft Row	Production per 10-ft Row	Average Pounds Consumed per Adult per Year		
			Fresh	Processed	Total
Asparagus	10	5-8 lbs	10	10	20
Bean, Green	35	6-8 lbs	15	25	40
Beet	50	10-12 lbs	3	4	7
Broccoli	10	10-12 lbs	5	6	11
Brussels Sprout	10	6-8 lbs	3	0	3
Cabbage	8	10-15 lbs	10	10	20
Carrot	60-80	12 lbs	8	8	16
Cauliflower	9	8-10 lbs	6	9	15
Celery	20	15 lbs	5	0	5
Chard, Swiss	20	30 lbs	3	5	8
Corn, Sweet	20	3 doz ears	17	33	50
Cucumber	5	2-3 doz	6	12	18
Eggplant	5	15 eggplants	2	3	5
Kohlrabi	30	7-8 lbs	4	2	6
Lettuce, Head	10	10 lbs	5	0	5
Lettuce, Leaf	30-60	5 lbs	5	0	5
Muskmelon (Cantaloupe)	3	10-15 melons	5	0	5
Onion, Bulb	40	10 lbs	10	0	10
Onion, Green	60-80	2 lbs	2	0	2
Parsnip	40	10-15 lbs	5	0	5
Pea	60-100	10-12 lbs	5	8	13
Pepper	6	20 lbs	3	7	10
Potato	10	20 lbs	70	0	70
Pumpkin	3	10 pumpkins	10	10	20
Radish	100-120	3 lbs	1	0	1
Rhubarb	3-4	15-20 lbs	5	5	10
Spinach	30-40	5 lbs	3	5	8
Squash, Summer	3	25 lbs	7	10	17
Squash, Winter	2	20-30 lbs	20	20	40
Tomato	8	30-50 lbs	35	50	85
Turnip	30-40	20 lbs	3	0	3
Watermelon	3	6-12 melons	10	0	10

Table 2. Differences in quality, production, and value between common home-grown and store-bought vegetables in Washington (adapted from Antonelli et al. 2004, 3).

Vegetable	Garden & Store Difference in Quality	Production per Square Foot	Relative Monetary Value
Asparagus	high[1]	medium	high
Bean, Green	medium[2]	high	medium
Beet	medium	high	medium
Bok Choy	low[3]	medium	medium
Broccoli	medium	high	high
Brussels Sprout	medium	low	high
Cabbage	low	low	low
Carrot	medium	high	medium
Cauliflower	low	medium	high
Celery	low	medium	medium
Chard, Swiss	high	high	medium
Collards	medium	medium	high
Corn, Sweet	high	low	low
Cucumber	medium	medium	high
Edamame	high	medium	high
Eggplant	medium	low	high
Kale	medium	high	high
Kohlrabi	low	medium	medium
Leek	medium	medium	high
Lettuce, Leaf	medium	medium	high
Lettuce, Head	low	low	medium
Muskmelon (Cantaloupe)	low	low	medium
Onion, Bulb	low	medium	low
Onion, Green	high	high	high
Parsnip	low	medium	medium
Pea	high	medium	high
Pepper	medium	low	high
Potato	low	medium	low
Pumpkin	low	low	low
Radish	low	high	medium
Rhubarb	medium	high	high
Spinach	medium	medium	medium
Squash, Summer	high	high	high
Squash, Winter	low	medium	low
Tomato	high	medium	high
Turnip	low	high	medium
Watermelon	low	low	low

[1]High indicates this home-grown vegetable is far superior to the store-bought version.
[2]Medium indicates this home-grown vegetable is somewhat superior to the store-bought version.
[3]Low indicates there is little difference between the home-grown and store-bought versions.

Table 4. Seeding recommendations for common vegetable crops grown in Washington (adapted from Kumar et al. 2009, 3-4).

	Seeding			Germination		Growth		
Vegetable	Depth to Plant (inch)	Distance Between Plants (inch)	Distance Between Rows (inch)	Number of Days to Germinate	Optimum Soil Temperature Range (°F)	Base Air Temperature (°F)	Weeks to Grow to Transplant Size	Days to Maturity
Artichoke	¼-½	18	36	8-14	65-82	50	6-8	85-120
Arugula	¼	6	10-12	7-14	45-75	40-55	DS[1]	30-40
Asparagus, Seed	1½	12	18-36	24-30	50-85	40	12-14	2-3 years
Asparagus, Crown	6-9	12	18-36	12-20	60-85	40	DS	1-2 years
Celtuce	¼	8	10-20	7-10	50-80	50-60	4-5	80
Bean, Bush	1½-2	2	18-30	6-14	60-90	50	DS	50-70
Bean, Lima Bush	1½-2	3	18-30	7-12	70-85	55	DS	75-80
Bean, Lima Pole	1½-2	3-4	24-36	7-12	75-85	55	DS	85-90
Bean, Pole	1½-2	3	24-36	6-14	60-85	50	DS	55-65
Bean, Scarlet Runner	1½-2	4-6	36-48	8-16	65-85	50	DS	60-70
Bean, Yardlong	1	3	24-36	6-13	60	50	DS	75-85
Beet	½-1	3	12-18	7-10	50-85	40	DS	45-55
Belgian Endive (Witloof Chicory)	¼-½	4-8	18-24	7-21	50-75	45	4-6	100-120
Black-Eyed Pea (Cowpea, Southern Pea)	1-1½	2-4	24-30	7-14	70-85	65	DS	105-125
Bok Choy	¼-½	4-12	10-18	5-14	50-80	45	4-5	30-50
Broccoli	¼-½	12-18	18-24	3-10	50-60	40	5-6	50-80
Brussels Sprout	¼-½	18-24	24-36	3-10	45-85	40	5-6	80-105
Cabbage	¼-½	12-24	24-36	4-10	50-90	50	5-6	65-95
Cabbage, Chinese	¼-½	10-18	18-30	4-10	60-85	50	4-6	70-90
Carrot	¼-½	1-2	12-24	7-21	50-75	45	DS	60-80
Cauliflower	¼-½	18	24-36	4-10	45-85	50	5-6	65-80
Celeriac	⅛	8	24-36	9-21	70-75	60	10	90-120
Celery	⅛	8	24-36	9-21	60-70	45	10-12	120-140
Chard, Swiss	½	4-12	18-24	7-14	50-85	40	DS	55-65
Chicory (Endive, Escarole)	½	8-10	12-24	5-9	50-80	40	4-6	50-60
Chicory, Italian Dandelion	¼-½	8-10	12-16	7-14	50-75	40	DS	45-55
Chive	¼-½	2-4	12-18	7-21	50-70	45	4-6	80-90
Collards	½-¾	8-18	18-30	4-10	40-85	40	5-6	65-85
Corn, Sweet	2	6-12	24-36	6-10	60-90	48	DS	65-90
Corn Salad (Mâche, Feldsalat)	¼-½	4-6	6-18	10-14	50-65	40	DS	45-55
Cress	¼-½	4-6	3-4	4-10	55-75	45	DS	25-45
Cucumber	1	12-18	36-48	6-10	70-95	55	4-5	45-65
Edamame	1½-2	2-3	24-30	6-14	55	50	DS	85-100
Eggplant	¼-½	18	24-36	7-14	70-90	60	6-9	75-95
Fennel (Finocchio)	¼-½	10-12	24-36	12-18	50-75	30	6-8	100-120
Garbanzo (Chickpea)	1½-2½	3-4	24-30	6-12	45	65	DS	85-125

[1]DS is direct-seeded.

Environmental Factors and Protections

Sun

Excess/harsh direct sunlight may cause plants to wilt or get sunburned/scalded.

Wind

Excess/harsh winds can break plant tissue, cause bruises, and even kill them.

Rain

Excess rain can “drown” plants, leading to wilting. Harsh rainfall/rainstorms can, like wind, break and damage plants.

Hail

Hail can lead to even more damaged plants than heavy rain or wind damage.

Pests

Pests damage plants through organismal (insects, animals, fungus, plants) damages by consumption, infestation, or even viruses.

Row cover

Fabric covering plants with metal hoops supporting said fabric to protect plants. Different fabric materials can help with insulation, breathing, controlling temperature and moisture, deflecting heat, reducing sunlight (with shades), and protect direct contact (hail, wind, rain, pests) damages to plants.

Mulch

Pieces of organic material (wood chips, leaves, grass…etc) covering soil. Provides moisture retention as well as temperature control both in summers and winter.

Cost Estimation

Preparation (Amount)	**Individual Costs**	**Annual Cost**
Water Protection	Geotextile Layer (15’ x 360’): $708 Per Roll Waterproofing layer: $9 Per Square Foot	$3000 < X
Tools (Variable)	---	$100
Soil (300 Bags)	$7.00 each	$2,100
Plants (Variable)	---	---
Hydroponic System (2 Each)	$500 each	$1000
Plant Containers (10 Per)	$10 - $40 each	$100 - $400
Raised Beds (Self Built)	Wood: $20-$50	
In-Ground Beds (Variable)	---	---
Irrigation System (drip)	$45 each	$180
Overall Total Cost	**$1,299 - $1,359**	**$6,480 < X**

*Costs will vary depending on size, amount of systems integrated, and amount and types of plants.

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