

Crop Management and Planning under Tunnels



MSU Tunnel Workshop, August 3rd 2016
Patrice Gros, Foundation Farm

Crop Management and Planning under Tunnels



Farm Philosophy: Organic, no-Till

- Optimal microbial life: natural soil texture and structure plus micro-biological "glue" form "aggregates" which creates an ideal ecosystem. Tilling destroys soil's natural texture, structure and micro-biome!
- Optimal water and air content: soil in its un-tilled, natural state optimizes water and air availability to plants and micro-organisms. Tilling cuts moisture and air capacity in half leading to heavier irrigation and repeated tilling.
- Optimal nutrient availability: undisturbed soil structure and biology optimizes nutrient accumulation/release, hence can reduce, and even eliminate the need for any fertilizer.

Plants are capable of producing "exudates" which attract specific micro-organisms (bacteria) which in turn can feed the plants throughout the extensive rhizosphere (root area). Rhizosphere can be vastly extended by fungal networks.

Tilling leads to more fertilizing, organic or conventional.



Fertility and Soil Management

Crop Management for Tunnels



- Same as for outdoor
- Straw mulch applied generously throughout the year (600 bales each year!!)
- Rabbit manure with a typical yearly application rate of 25#/100 square feet.
- Plant residues...NO EXTRANEIOUS COMPOSTING!
- Grass clippings from the paths.
- Feather meal prior to a nitrogen-hungry crop like spinach or arugula (2#/100sq. feet)



Crop Management for Tunnels



Fertility and Soil Management

The following soil test was done for one of our low tunnels following 8 years of year-round production, including winter. Notice the extremely high organic matter content (8.6%), a sign of soil health and fertility.

U of A		DIVISION OF AGRICULTURE RESEARCH & EXTENSION University of Arkansas System		Client ID: 419837003	
Cooperative Extension Service Soil Testing And Research Laboratory Mansfield, AR 72063 http://soiltest.uark.edu		SUKESKA SPRINGS		AR	10822
The University of Arkansas is an Equal Opportunity/Affirmative Action Institution		Date Processed:	3/14/2016	Field ID:	2582.1
		Acid:	7	Location in field:	---
		Line depth in the soil (inches):	0-8	Location in year (4 years):	---
		Moisture:	13.0000%	Plant:	---
		Grain:	---	Lab Number:	46678
		Lab Number:	46678	Sample Number:	3/13/2016
		Sample Number:	3/13/2016		
Nutrient Availability Index		Soil Test Level (Minimum %)		Soil Properties	
Element	Concentration	Actual	Optimum	Value	Index
N	331	362	None Optimum	2.2	---
P	271	842	None Optimum	15.91	100000
K	2738	5478	None Optimum	1.8	---
Ca	3961	795	---	---	---
Mg	12	26	---	---	---
Na	22	52	None Optimum	---	---
Fe	123	244	---	---	---
Cu	0.04	0.08	---	---	---
Zn	0.9	17.5	---	---	---
		Cation Exchange Capacity (CEC)		Cation Exchange Capacity (CEC)	
		100	Ca	Mg	K
		88.00	88.48	16.70	0.32

Bed Lay Out

Crop Management for Tunnels



- Beds in the direction of the tunnel as in the pictures below. The 17 feet across the low tunnels are divided this way: 1 foot trench, 3 foot bed, 2.5 foot path, 4 foot bed, 2.5 foot path, 3 foot bed, 1 foot trench.
- Ratio bed surface over total surface is 1,000/1,700 = 60%
- 1 foot wide trenches along both sides of my low tunnels, mulched year round for extra drainage and cold protection



Temperature

Winter Crop Management



- High and low tunnels are effective use of technology to regulate extreme temperatures. In Northern Arkansas, we are able to grow food through the entire winter.
- In addition to the tunnel itself, each growing bed gets its own row cover (medium grade) which is laid out metal wire arches.
- The compound effect of tunnels and covers provides protection down to zero degree.




Winter Crop Management 

Mulch


- Beds are cleared of mulch and of summer plants (mostly tomatoes). Mulch is pushed out to the sides or stacked in front of the tunnels. The bed is then raked clean and made ready with irrigation lines to receive the seedlings.
- Mulch is used on some crops (bokchoi, onion) to reduce weed pressure.





Winter Crop Management 

Pest & Disease Management


- Usual suspects in winter are white flies and aphids, possibly spider mite. Treat with insecticidal soap and/or oil (Safer Soap)
- Crop rotations can help but they are limited by the amount of total space available under tunnel.
- No-till soil is generally capable of keeping soil imbalances and nutrient depletions at bay.



Winter Crop Management 

Weed Management

- Main weed is chickweed, an edible which is hard to eliminate.
- My strategy: mix of hoeing and mulching depending on the crop and the development stage of the crop.
- Here is a picture showing fescue and chickweed in a bed of lettuce about to be harvested. Once all lettuces harvested, the weeds will be raked out before a second wave sowing.



Winter Crop Management 

Irrigation

- Drip tape (2 per bed). Sub-freezing temperatures can break valves and pipes, so the irrigation lines are drained regularly in winter.
- Watering is rare in December and January, maybe every other week; more if it is unusually sunny and warm.
- Often moisture will be made available in the soil through extensive periods, following heavy rains or snows.



Summer Crop Management 

Temperature

Beds can easily overheat in summer. Cooling is provided in many ways:

- Cross ventilation: plastic is rolled up on sides and off-wind end is always open.
- Mulch: soil is cooled by mulch
- Shading cloth: if needed 50% shading fabric can be.




Summer Crop Management 

Mulch

Beds are progressively readied for summer with full-on mulch and opened up to receive tomato transplants starting in mid-May.




Summer Crop Management 

Pest & Disease Management

- Usual suspects on summer tomatoes are tomato and horn worms; both treated with BT (Dipel) with one or 2 weekly sprays.
- Occasional blister beetles are sprayed with Piganic (Morgan Seed Co), a pyrethrum extract spray.
- Main issue with tomato (blight) is almost entirely controlled by the tunnels shielding plants from rain.





Summer Crop Management 

Weed Management

100% control through use of heavy mulch during entire summer




Summer Crop Management 

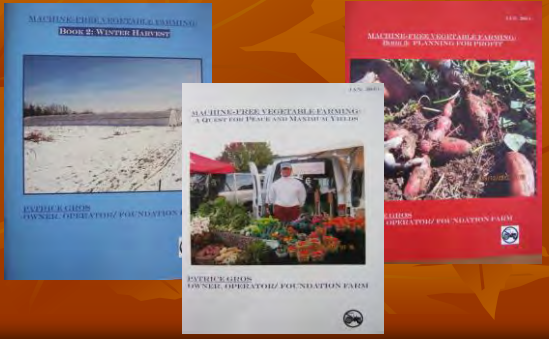
Irrigation

Drip tape (2 per bed) is used to reproduce the effect of long rain storms through all night irrigation rounds once a week.



Summer Crop Management 

My gardening/farming books are available for \$10 each or \$25 for all 3!!!



Crop Planning under Tunnels 


Challenge: to produce a continuous supply of food, while the weather goes wild and freezing nights want to kill all you grow.

The timing of crops painstakingly learned for the other seasons is suddenly useless.

Because of these extreme weather conditions, planning and timing is critical.




This market table on January 31st 2013 had kale, chard, spinach, lettuce, mustard, bok-choi, collards, parsley, cilantro, turnip, and carrot.

Crop Planning under Tunnels 

Planning Strategy

- Tunnels are used for higher yields and income throughout the year, not just in winter.
- The year breaks down between winter (10-5) and summer (5-10)
- Winter and summer call for very distinct timing and cultivation strategies.



Winter Crop Planning


Planning Factors

Temperature

- Tunnels provide a 1-month calendar shift so December becomes November, and January becomes February. In effect, December and January "do not happen".
- Tunnels eliminate the risk of crop total freeze and death.

Crop Hardiness

- Learn various crops' abilities to face fierce cold weather. Your climate zone will greatly affect this. Foundation Farm is in Zone 6A.
- Certain crop sub-types or varieties will outperform their siblings in harsh weather.
- Position crops within the tunnels according to their relative hardiness (hardest in outside beds, as in kale in side picture)



Winter Crop Planning

Marketability

- Stars: carrot, spinach, kale, lettuce, baby mix
- Supporting cast: arugula, cilantro, turnip, scallions, chard
- Extras: collard, mustard

Market outlets can affect the list.

Growing Ability


- My winter list of "problem-crops": spinach, carrots, and cauliflower. Reasons include poor germination, questionable hardiness, sensitivity to insects, diseases and weeds, and more.
- My winter list of dream (easy, marketable) crops: lettuce, cilantro, arugula, bok-choi and kale.

Keep in mind that some varieties will stand out in term of hardiness or overall adaption to our area.



Winter Crop Planning

	direct seeded vs. transplant	market potential	multiple harvest	cold hardiness	notable varieties
bokchoi	ds/t	**	yes/no	**	black summer, tatsui
cabbage	t	**	no	**	copenhagen
arugula	ds	***	yes	***	
baby greens	ds	***	yes	**	red salad bowl, mizuna, tatsui, red russian kale
lettuce	t	**	no	**	magnolia, panisse
mustard	t	*	yes	**	green giant
kale	t	***	yes	**	albanian, reflex
chard	t	**	yes	**	
collard	t	*	yes	***	
spinach	ds	***	yes	***	lyee, space
parsley	t	**	yes	**	
cilantro	ds/t	***	no	**	santo
mache	ds	**	no	***	
japanese turnip	ds	**	no	**	
purple top turnip	ds	*	no	***	
carrot	ds	***	no	***	
radish/daikon	ds	**	no	**	cherry belle
leek	ds/t	**	no	**	
green onion	ds/t	**	no	**	evergreen



Winter Crop Planning

Soil Readiness/Fertility


- So far (8 years), winter has not generated any particular fertility requirement from overall farm strategy (organic matter, feather meal)

Plant Density

- A direct result of fertility, and light access
- Experimenting now with denser plantings
- Up to 5 lines of lettuce on a 4 foot bed
- Up to 7 lines of cilantro on 4 foot bed

Plant Positioning

- Factors: hardiness, shape and size
- Position in the tunnel
- Position in the bed



Winter Crop Planning


Overall Profitability

- All above factors bottom line with profit/square foot/month
- Lettuce bed on the right reached a record \$1,000 in November of 2015.


Plant Rotations

- Faced with a restricted cultivated area (under tunnel), and limited choices of plants, winter rotations are next to impossible to plan for. It is fortunate that the overall health of our soil allows for the by-passing of rotation, a golden rule of organic farming.

Nevertheless, we try to alternate the few families of plants that we can play with.



Winter Crop Planning



The 2 Wave Planning System

Winter Crop Planning

1st Wave: September-December:

- Progressive replacement of summer plants (tomatoes, peppers)
- Critical time to gain maximum growth before cooling off
- Most beds are seeded or planted by December 1st
- December-January: slowest growth, production is from mature plants.

Lettuce replacement of tomatoes in September

Mature lettuce ready for harvest in late November

The 2 Wave Planning System

Winter Crop Planning

2nd Wave: January-March

- Progressively replacing the harvested beds from the first wave with new crops (see planning table), which will have until **May 15th/June 1st** when tomatoes reclaim their space...
- Transplanting is not recommended in the coldest Jan-Feb period. Seeding of the hardest crops can be pursued (spinach, radish, kale...)

1st wave lettuce in November

2nd wave baby greens seeded in January

Winter Crop Planning

dates	sow trays	transplant	direct seed	harvest
08-01 to 08-30	lettuce, bok-choi, leek, scallion, beet		carrot, beet, turnip, bok-choi, arugula	summer crops
9-01 to 9-15	bok-choi, lettuce, chard, kale, meathard, collard, parsley, cilantro, leek, scallion	lettuce	arugula, baby greens, carrot, turnip, radish, bok-choi	summer crops
9-15 to 9-30		lettuce, bok-choi, leek, scallion, beet		summer crops, turnip, bok-choi, arugula
10-01 to 10-15	bok-choi, lettuce, spinach	lettuce, bok-choi	arugula, baby greens, carrot	summer crop, lettuce, bok-choi, arugula, scallion, beet, baby greens
10-15 to 10-30			spinach	lettuce, bok-choi, scallion, beet, carrot, baby greens
10-30 to 11-15	spinach	lettuce, bok-choi	arugula, baby greens, carrot, turnip, radish, mache	lettuce, bok-choi, scallion, beet, carrot, baby greens
11-15 to 12-30		spinach	spinach	spinach, lettuce, bok-choi, big greens, parsley, cilantro, arugula, baby greens, leek, scallion, carrot, turnip, radish
01-01 to 02-15		spinach	arugula, baby greens, radish, turnip, bok-choi, mache	spinach, big greens, parsley, cilantro, arugula, baby greens
02-15 to 04-15				spinach, arugula, baby greens, radish, turnip, bok-choi

■ Sow in trays
■ Transplant
■ Direct seed
■ Harvest

Summer Crop Planning

Planning Factors

Temperature

- Tunnels provide a shift of at least one climate zone allowing hot crops like peppers and eggplants to thrive.
- Tunnels extend season on hot crops by up to one month on each side of the season because of freeze protection.

Crop Hardiness

- Tomatoes are extremely sensitive to rain-induced blight in our humid summers. Tunnels are the perfect solution. Blight free yields can be tripled.
- Other issue is overheating (nights over 80) which can stop blooms. Shade cloth can be added atop the tunnels.

Summer Crop Planning

Marketability

- Tomatoes, peppers and eggplants are in demand but can be over-supplied.
- Using several varieties, including cherry tomatoes, and heirlooms can help.

Growing Ability

- Only issue is early start for plants which might be struggling in the cool, un-tilled soil.
- A late mid-May to early June transplanting is recommended and compatible with the end of all the winter crops.

Summer Crop Planning

Soil Readiness/Fertility

- Summer fertility is optimal as soil biology is reaching its peak.

Plant Density

- Tomatoes, peppers and eggplants are set 2.5 feet apart in the row (3 to 4 foot wide)

Plant Positioning/Caging vs Trellising

- Determinate tomato types (romas, most hybrids, few heirlooms) are set on the outside bed and caged in "half cages" (4 foot tall).
- Indeterminate tomatoes (most heirlooms) are set in the middle beds and trellised.

Crop Management and Planning under Tunnels



The Bottom Line

	LT 1				LT 2				LT 3				HT				total sq. feet
1st wave 09-11	250	350	250	250	250	350	250	250	250	350	250	250	250	400	400	250	4250
1st wave months	3	3	4	3	3	3	5	3	3	4	5	3	4	5	5	0	
1st wave revenue	\$450	\$630	\$400	\$450	\$598	\$563	\$450	\$500	\$500	\$800	\$0	\$0	\$350	\$0	\$0	\$350	\$6,500
1st wave costs	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
1st wave net	\$450	\$630	\$400	\$450	\$598	\$563	\$450	\$500	\$500	\$800	\$0	\$0	\$350	\$0	\$0	\$350	\$6,500
2nd wave 12-03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
2nd wave months	4	4	3	3	5	0	4	3	3	0	4	4	3	0	0	0	
2nd wave revenue	\$400	\$400	\$300	\$300	\$700	\$0	\$300	\$473	\$300	\$0	\$500	\$500	\$263	\$0	\$0	\$0	\$2,436
2nd wave costs	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
2nd wave net	\$400	\$400	\$300	\$300	\$700	\$0	\$300	\$473	\$300	\$0	\$500	\$500	\$263	\$0	\$0	\$0	\$2,436
Year Total	\$850	\$1,120	\$700	\$750	\$1,698	\$563	\$750	\$973	\$800	\$0	\$500	\$500	\$613	\$0	\$0	\$0	\$11,220
Year Total	\$2,870	\$3,010	\$2,513	\$2,513	\$3,033	\$0	\$3,033	\$3,033	\$3,033	\$0	\$3,033	\$3,033	\$3,033	\$0	\$0	\$0	\$12,975
Year Total	\$1,600	\$1,600	\$1,600	\$1,600	\$1,600	\$0	\$1,600	\$1,600	\$1,600	\$0	\$1,600	\$1,600	\$1,600	\$0	\$0	\$0	\$12,800
Year Total	\$1,600	\$1,600	\$1,600	\$1,600	\$1,600	\$0	\$1,600	\$1,600	\$1,600	\$0	\$1,600	\$1,600	\$1,600	\$0	\$0	\$0	\$12,800

additional summer income assuming all tomatoes between June 1st and November 1st (6 months):

4250 square feet X \$30/month/square foot X 6 months = 12,750

Year Total: \$12,750

Year Total: \$23,975

Year Total: \$12,800

Year Total: \$12,800

My gardening/farming books are available for \$10 each or \$25 for all 3!!!

