Northern New York Agricultural Development Program
2021 Project Final Report

Extending the Season in Northern New York with Brassica Crops

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This report is split into three distinct sections with sections. Sections 1 and 2 cover the research trials, each with Background, Methods, Results and Discussion, and Conclusions sections, while section 3 provides an overview of the grant's outreach activities.

SECTION 1:
Sprouting Broccoli and Miniature Cabbage Planting Date and Variety Trial

Background:

Providing a diverse offering of vegetables for early spring CSA shares and markets can be a challenge for Northern New York growers. Offerings usually consist of leftover storage root crops, salad greens, and radishes. Due to their cold tolerance and quick growth, brassicas are promising crops for cool spring high tunnel environments. In 2021, we trialed five varieties of sprouting broccoli and four varieties of small cabbages at the Cornell Willsboro Research Farm to develop seeding date and variety recommendations for the Northern New York region. We harvested fresh broccoli and tender cabbages in mid-May 2021—excellent timing for the start of farmers market season.

Spring broccoli is commonly grown in England in the winter, and includes green, purple, and white varieties. Rather than forming one large crown, sprouting broccoli produces a small crown and many lateral shoots. The small floret, stem, and attached leaves of the sprouts are all edible, either steamed, roasted, boiled, or fresh. Some prefer to call sprouting broccoli "asparagus broccoli" because it can be prepared similarly to asparagus. Sprouting broccoli has a mild flavor, and stems are very tender.

Two types of sprouting broccoli varieties are available: those that require a short exposure to cold in order to form florets (low vernalization varieties for spring/summer) and those requiring long cold exposure (high vernalization varieties for fall/winter). High vernalization varieties of broccoli can be overwintered in unheated high tunnels in the Northeast. The plants are transplanted in September or October and grow until mid-November. The plants lay dormant in the winter until days grow longer in February; they are harvested in March – May. Low vernalization varieties can be planted in the early spring and do not require overwintering. At the Willsboro Farm, we grew two low vernalization varieties in our spring trial, transplanted in March. In our fall trial, we grew three high vernalization varieties, transplanted in September.

In addition to the sprouting broccoli, we grew miniature cabbages in the Willsboro Farm high tunnel in the spring. Our interest in miniature cabbages arose from consumer trends toward smaller vegetables. Small cabbages are easier for smaller households to prepare and store. In particular, some small varieties are especially well suited for fresh salads and have very tender, lettuce-like leaves. Fresh cabbage in May is arguably much better eating quality than cabbages that have been in storage since the previous fall. Tender cabbages are used in place of lettuce in Eastern European cuisines. In this NNYADP trial, we were interested in comparing yields at two different seeding dates of the trial's broccoli and cabbage varieties in spring 2021.

Methods:

Spring trial: Low vernalization sprouting broccoli and cabbages

We seeded 'Burgundy' and 'Montebello' (Fig. 1), two low vernalization varieties of sprouting broccoli and the 'Tiara', 'Katerina', 'Caraflex', and 'Omero' varieties of small cabbages (Fig. 2) on February 15 ("early" seeding) and March 1, 2021 ("late" seeding; Fig. 3) in 128-cell trays using a compost-based potting mix. All varieties were obtained from Bejo Seeds with the exception of 'Caraflex' (Johnny's Selected Seeds).

A neighboring farm grew our seedlings for us in a heated propagation greenhouse until they were ready to transplant. We transplanted the seedlings into the unheated 30 ft x90 ft high tunnel at the Willsboro Research Farm on March 22. We used 80 lbs of pre-plant nitrogen per acre (N/ac) for broccoli and 20 lbs of pre-plant N/ac for the cabbages and applied potassium (K) according to our soil test results using Pro Booster (10-0-0) and sulfate of potash (0-0-52). All plants received fertigation with a complete fertilizer (5 lbs N/week) when deficiency symptoms appeared at crop heading.

We grew both crops in 4 ft-wide beds each with two lines of drip tape, with 12 in by 12 in plant spacing for the broccoli and 12 in x 6 in spacing for the cabbage. We arranged the plots in a randomized complete block design in the high tunnel, with six replicates per treatment (variety and seeding date combinations). The plots were 4 ft x 3 ft (broccoli) and 4 ft x2 ft (cabbage) in size (Fig. 4). Each broccoli plot contained 12 plants, and each cabbage plot contained 16 plants.

The spring weather was unseasonably warm in Willsboro, and we used Typar row covers (1.25 oz/sq yd) at night only a few times when temperatures dropped below 32°F as the plants were getting hardened off in the tunnel.

Imported cabbageworms and voles were our major pests in the tunnel. We managed these successfully with DiPel and snap traps.

The sprouting broccoli was ready to harvest on May 21, 2021. We harvested the "main" crowns, and thereafter harvested the sprouts 1-3 times per week until the plants began to bolt and quality declined in late July.

Harvest of the cabbage was more sporadic, with harvest beginning on May 26, 2021 for some varieties and extending through July. We weighed the crop harvested from our plots, and measured the diameters and individual head weights of the cabbages. To determine significant differences in total yield between seeding date treatments and varieties, we conducted factorial analysis of variance (ANOVA) tests using JMP statistical software (vers. 15).

Winter trial: High vernalization sprouting broccoli

Following the last harvest of our spring trial brassicas, we removed all plant material and left the tunnel fallow until we used the same space for our winter broccoli. We seeded the winter (high vernalization) broccoli varieties of 'Bonarda,' 'Mendocino,' and 'Santee' on August 27 and September 10, 2021, using the same methods used for our spring trial.

Prior to transplanting, we applied peat moss and prepared the beds and experimental plots using the same methods described previously for the spring broccoli trial.

DiPel (Bt) and various rodent traps were used to manage pests in fall 2021.

When nighttime temperatures consistently dropped below freezing in late November 2021, the beds were covered in thick Typar row cover (1.25 oz/sq yd) for the winter (Fig. 5). Hoops placed at the end of each plot allowed the cover to float above the top of the plant canopy.

Because very few plants survived the 2021-2022 winter and produced broccoli (5% of total experiment), we were unable to collect yield data from this experiment. On April 18, 2022, we recorded the number of winter broccoli plants that had survived the winter and had begun producing broccoli florets.

Enterprise budgets: For each crop, we tracked expenses and yield in order to develop enterprise budgets and income estimates. An enterprise budget is a crop-specific detailed budget that includes costs associated with supplies (seeds, fertilizer, etc.), labor, infrastructure, equipment, and all other expenses for growing and harvesting the crop. To obtain gross income estimates for selling each crop, we used a range of prices per pound based on those charged by farms in Essex County. Using our budgets, yields, and gross income estimates, we generated net income estimates for growing a 4 ft x90 ft bed or full high tunnel (four beds) of spring broccoli or cabbage. Because the winter broccoli performed poorly, we did not develop an enterprise budget for this crop. Enterprise budgets for our spring broccoli and cabbage crops are found in the Appendix.

Results and Discussion:

Spring trial: Low vernalization sprouting broccoli and cabbages

The low vernalization varieties of sprouting broccoli 'Burgundy' and 'Montebello' yielded statistically-similar amounts of sprouting broccoli crowns and shoots ($p > 0.05$). While plants from both seeding dates were ready to harvest at the same time in late May, the early-seeded (February 15) plots yielded significantly more broccoli ($F_1 = 8.6611$, $p = 0.0095$). Extrapolated to a full-bed length (4'x90'), our average yields from the early-seeded plots were 125 lbs ('Burgundy') and 131 lbs ('Montebello').

A grower could grow both of these varieties and sell them in mixed bunches or bags. The green and purple hues of these varieties look very attractive together. Nearly half of the total yield from our plots was from the "main" crowns, and most of the yield was harvested before June 1 (Fig. 6). These crowns could be sold 3-4 in a bunch, rubber banded together. Not all of the sprouts we harvested had long stems, so bagging these would likely be the best way to market them. No washing or leaf stripping would be needed for the broccoli. Growers could likely obtain a premium price for fresh broccoli in May, given that fresh broccoli isn't typically available until July grown in the field.

For our cabbages, there were stronger varietal differences, but, similarly to the broccoli, seeding date had little effect on harvest date ($p > 0.05$). Variety significantly impacted yield ($F_4 = 22.3492$, $p < 0.001$). The highest yielding variety was early-seeded 'Tiara', with 0.99 lbs/sq ft (356 lbs per 4 ft x90 ft bed extrapolated; Fig. 7). Late-seeded 'Caraflex' and 'Tiara', and both seedings of 'Katerina' yielded similarly; early-seeded 'Caraflex' produced slightly lower yields. We harvested significantly lower yields of 'Omero', the only purple cabbage in our trial. Most plants failed to form heads that were larger than a baseball, and were still not ready to harvest by August 1, 2021, when we terminated the trial. Most cabbages were ~4 in in diameter with outer leaves removed and weighed approximately 0.5 lbs. For marketing purposes, heads looked more attractive with loose, darker green outer leaves intact.

Winter trial: High vernalization sprouting broccoli

Few fall-planted sprouting broccoli plants survived the winter in Willsboro. The 2021-2022 winter was particularly cold, with many nights below 0ºF. Overall, 15% of the plants in the trial (63 of the 432 planted) survived the winter, showing signs of green growth during our April 18 data collection. Only 5% produced broccoli florets in the spring, although many were not marketable. Many plants producing broccoli florets were significantly stunted due to cold stress from the winter. Of the varieties tested, Mendocino resulted in the highest number of plants producing florets (16 of 38 surviving), followed by Santee (5 of 5 surviving), whereas no Bonarda plants (0 of 20 surviving) produced broccoli in the spring.

Enterprise budgets

Our dense spring 2021 cabbage planting resulted in a much higher yield on a per-tunnel basis versus sprouting broccoli: 1,424 lbs versus 525 lbs for the most productive variety and seeding date treatments, respectively, and, as a result, spring cabbage may be more profitable (Table 1 and Appendix). Although sprouting broccoli may fetch a higher price per lb ($8/lb) than cabbage ($6/lb), the cabbage yields were nearly double that of broccoli. Therefore, based on volume, spring cabbage may be a more lucrative crop for spring markets, if there is sufficient consumer interest.

In our enterprise budgets, we include pricing scenarios in which growers terminate the crop at the end of June in order to plant a late summer crop with more time to mature before a frost. Budgets and profitability estimates will vary greatly by farm according to market type and pricing.

Table 1. Net income of broccoli and cabbage crops based on enterprise budgets, Willsboro Farm experimental yield, and pricing scenarios (Appendix). Estimates reflect crop termination on either August 1 or in late June with lower yields. NNYADP Brassica Crops Trials, 2021.

Crop	Net income Aug. 1 termination		Net income Late June termination	
	Per tunnel[1]	Per 4’x90’ bed	Per tunnel	Per 4’x90’ bed
SPRING				
Spring broccoli[2]	$1,601 - $2,642	$400 - $660	$680 - $1,395	$170 - $349
Spring cabbage[3]	$4,068 - $6,916	$1,017 - $1,729	$3,125 - $5,471	$781 - $1,368
WINTER				
Winter broccoli[1]	NA due to crop failure			

[1]Assume 30 ft x96 ft tunnel with four 4 ft x90 ft beds.

[2]Income range based on retail prices of $6-$8/lb broccoli

[3]Income range based on retail prices of $4-$6/lb cabbage (approx. $2-$3 per head)

Table 2. Gross income comparison of overwintered broccoli versus overwintered spinach. NNYADP Brassica Crops Trials, 2021.

Crop	Gross income comparison	
	Per tunnel[1]	Per 4’x90’ bed
WINTER		
Winter broccoli[2]	NA due to crop failure	
Winter spinach[3]	$15,631 – 18,036	$3,908 - $4,509

[1]Assume 30 ft x96 ft tunnel with four 4 ft x 90 ft beds.

[2]Income range based on retail prices of $6 - $8/lb broccoli

[3]Income range based on $13 - $15/lb spinach and mean yield from Willsboro Farm across winters 2019 – 2020 and 2020-2021

Conclusions:

Being the first to market in the spring with cabbage and broccoli presents a marketing opportunity for Northern New York growers interested in diversifying their product offerings.

The broccoli and miniature cabbages we grew all had excellent eating quality, but may require consumer education in preparation and use. All varieties were easy to prepare, and all harvested parts are tender and edible.

From the growers' perspective, quick-growing spring brassicas may fit well into existing rotations. Spring-planted broccoli and cabbage could fill a niche in crop rotations, planted after winter spinach is removed in late March and harvested before a late cucumber or other warm season crop is planted in July. These specialty crops could fit nicely into existing rotations on farms while offering a novelty to farmers' market customers, CSA members, or restaurants highlighting local produce.

Based on our enterprise budgets, yield data, and potential pricing scenarios, we found that spring cabbage would potentially be more profitable than sprouting broccoli due to higher yields.

Due to crop failure in our winter broccoli trial, we do not recommend overwintered sprouting broccoli in Northern New York, despite its success in New Hampshire and Maine. Overwintered spinach is undoubtedly a far more profitable use of winter high tunnel space for producers in our region (Table 2). Spring planted sprouting broccoli and cabbage were more reliable crops in our trials.

SECTION 2:
Brassica Cover Crops Planting Date and Variety Trial

Background:
Including cover crops in crop rotations any time of the year can improve soil health in many ways, including reduction in erosion from rain and wind, improved water retention, increased organic matter, weed suppression, and more. Cold-tolerant brassica crops, including forage radish and mustards, are excellent options for fall cover crops in northern climates. When established in late summer, brassicas will produce a large quantity of biomass in the fall until a hard freeze in November or December. Radishes and mustards germinate quickly, crowding out weeds. Forage radishes produce deep taproots that scavenge nutrients, break apart hardpans, and improve soil structure. Both radishes and mustards die over winter, making them ideal for reduced tillage vegetable systems. Additionally, mustard crops produce biofumigant compounds that suppress plant pathogens and other soilborne pests.

In August and September 2021, we established plots of four different varieties of forage radish, and one variety of mustard across four planting dates at the Cornell Willsboro Research Farm. Our research questions were: 1) How late can you seed brassica cover crops in Northern New York for soil coverage and maximum biomass production?; and 2) Which forage radish variety best suppresses weeds? We selected these two questions to help address grower needs in Northern New York. Growers often consult us regarding concerns as to whether it's "too late" to seed a cover crop in the fall, and are interested in selecting cover crops with multiple benefits to soil and weed control. With the loss of the popular and original 'Tillage Radish' cultivar a few years ago, we were interested in whether other forage radish varieties would perform well for biomass production and weed suppression.

Methods:

The field site used for our cover crop experiment at the Willsboro Farm is a well-drained Stafford sandy loam. Prior to seeding, we applied 200 lbs/ac of 6-24-24 (N-P-K) and 100 lbs/ac of 39.75-0-0 (urea and ammonium sulfate) to supply nutrients for cover crop establishment. The field had been mixed grasses and legumes prior to its use for our trial. The field did not receive irrigation during the season and was cultivated prior to each seeding.

Using a randomized complete block design grouped by seeding date, we seeded our cover crops of radish and brown mustard varieties (Table 3) in 5 ft x10 ft plots on four different seeding dates: August 6, 16, and 26, and September 7, 2021. The varieties were seeded using a Great Plains cone seeder, with four replicates per variety and seeding date treatment. Our cover crop variety treatments included four radishes, one mustard variety, and an unplanted weedy control (Table 3). The weedy control plots were left fallow and undisturbed after each seeding date.

Table 3. Cover crop varieties used in 2021 trial. NNYADP Brassica Crops Trials, 2021.

Cover crop variety		Source	Seeding rate
Radish	'Carwoodi'	Albert Lea Seed (MN)	8 lbs/ac
	'Groundhog'	Territorial Seed Co. (OR)	
	Oilseed	Johnny's Selected Seeds (ME)	
	'Tapmaster'	Albert Lea Seed (MN)	
Brown mustard	'Pacific Gold'	Albert Lea Seed (MN)	17 lbs/ac
Unplanted weedy control	-	-	-

We selected the four forage radish varieties in this trial due to their commercial availability from prominent seed companies, regional popularity, and claims of weed suppression, establishment, and soil-building benefits. Of the four radish varieties, 'Carwoodi' has a bulbous root; the other three have a cylindrical, long taproot.

Aboveground cover crop and weed biomasses and belowground root biomasses were sampled on October 27, 28, and 29, 2021. Using one 0.5 m^2 quadrat per plot, we cut aboveground plant matter at ground level and removed roots by hand. We sorted aboveground biomass into weeds and cover crops, placed them separately into paper bags, and dried all bags in a drying oven for one week prior to weighing. We sampled roots from radishes only and recorded fresh biomass; roots were not dried.

In addition to biomass sampling, we recorded visual observations throughout the season on establishment, bolting, and other varietal characteristics. To determine significant differences in biomass between seeding date treatments and varieties, we conducted factorial analysis of variance (ANOVA) tests using JMP statistical software (vers. 15).

Results and Discussion:

Both the cover crop variety and the seeding date significantly influenced aboveground cover crop biomass in our overall model ($F_{4,4} = 3.6737$, $p = 0.0097$ and $F_{3,3} = 49.2016$, $p < 0.001$, respectively). Although establishing cover crops mid-summer can be risky when heat and dry weather impact germination, all varieties established well in our experiment with natural rainfall. All variety and seeding date treatments except for the September seeding generated 100% ground cover by the end of the fall. Our biomass measurements, taken at the end of October, reflect near-maximum crop growth potential for the season for all varieties, as short days and low temperatures cause plant growth to slow significantly in early November.

Across all seeding dates, mustard and ‘Carwoodi’ radish produced significantly more aboveground biomass than the other crops, with ‘Groundhog’ radish producing the least (Table 4 and Fig. 8). Mean dry aboveground cover crop biomass ranged from 73 g/0.5m^2 (‘Groundhog’) to 108 g/0.5m^2 (‘Carwoodi’ radish). ‘Carwoodi’ radishes, particularly in the early August and mid-August seedings, produced large, woody stalks and dense leaf matter. Both oilseed and ‘Carwoodi’ radishes bolted most frequently among the radish varieties. Mustard plants in the first three plantings grew very tall and flowered, attracting pollinators to the experimental plots.

All cover crops performed well to suppress weeds, and no significant differences were detected in weed biomass across varieties ($p > 0.05$; Fig. 8). As expected, the unplanted control plots contained the most weeds in all plantings.

All varieties established quickly and out-competed weeds at each planting date. Weed populations in our plots included predominantly lambsquarters, pigweed, and grasses in our early August and mid-August seedings, transitioning to winter annuals (mustards and shepherd’s purse) in our late August and September seedings.

Similarly to aboveground biomass, root biomass was significantly influenced by both cover crop variety and seeding date ($F_{3,3} = 9.6972$, $p < 0.001$ and $F_{3,3} = 33.7976$, $p < 0.001$, respectively). Root biomass was similar across all radish varieties with the exception of ‘Carwoodi’, which produced significantly lower biomass (Table 4, Figs. 9 and 10). ‘Carwoodi’ radishes were bulbous rather than having long taproots (Fig. 10). ‘Carwoodi’ radishes produced purple flowers, dense stalks, higher aboveground biomass, and lower root biomass in comparison to the other radish varieties.

Table 4. Mean aboveground cover crop, weed, and belowground radish root biomasses in experimental plots by variety across all seeding dates. NNYADP Brassica Crops Trials, 2021.

Cover crop variety		Aboveground dry biomass g/0.5 m^2		Belowground fresh radish biomass g/0.5 m^2
		Cover crop	Weeds	
Radish	‘Carwoodi’	103.9 ± 17.3A[1]	1.0 ± 0.4 B	206.1 ± 37.4 B
	‘Groundhog’	72.9 ± 7.7 B	0.5 ± 0.3 B	566.5 ± 113.7 A
	Oilseed	93.6 ± 11.6 AB	0.6 ± 0.4 B	626.5 ± 138.3 A
	‘Tapmaster’	84.6 ± 9.8 AB	0.4 ± 0.2 B	624.5 ± 119.5 A
Brown mustard	‘Pacific Gold’	107.6 ± 17.2 A	1.1 ± 0.4 B	-
Unplanted	-	-	32.5 ± 6.9 A	-

[1]Means ± standard error with different letters are statistically significantly different based on Tukey’s pairwise comparison *post hoc* tests ($p < 0.05$).

Our results indicate that in order to maximize aboveground and belowground cover crop biomass, the crop must be seeded before late August/September (Table 5, Figs. 8, 9, and 11). Biomass production decreased with later seeding dates. Weed pressure decreased with later seeding dates as well; overall weed biomass was lowest in plots seeded after mid-August. Large roots, produced from earlier plantings, are thought to sequester more nutrients to be released in the spring, and provide more feed for livestock when pigs, sheep, and other animals are rotated into radish plots. September-seeded plots produced very little aboveground and belowground biomass (Fig. 11).

Table 5. Mean aboveground cover crop, weed, and belowground radish root biomasses in experimental plots by seeding date across all varieties. NNYADP Brassica Crops Trials, 2021.

Seeding date	Aboveground dry biomass g/0.5 m^2		Belowground fresh radish biomass g/0.5 m^2
	Cover crop	Weeds	
Aug. 6	138.1 ± 11.0 A[1]	12.1 ± 5.7 A	958.4 ± 127.4 A
Aug. 16	120.4 ± 9.7 A	6.3 ± 2.6 B	646.8 ± 101.4 B
Aug. 26	77.3 ± 4.25 B	2.6 ± 1.1 B	321.4 ± 31.4 C
Sept. 7	34.4 ± 4.48 C	3.2 ± 1.6 B	97.1 ± 12.5 C

[1]Means ± standard error with different letters are statistically significantly different based on Tukey's pairwise comparison *post hoc* tests ($p < 0.05$).

Conclusions:

To maximize the benefits of brassica cover crops, one should seed them before late August in Northern New York. Even during the region's warm 2021 autumn, our September-seeded cover crops did not provide enough growth for complete ground cover. These results are in agreement with predictions from the Cornell Climate Smart Farming Winter Cover Crop Scheduler model. We measured the most root growth in our August 6 and 16 seedings, indicating that these roots would potentially sequester more nutrients for subsequent crops in the following spring, although we did not test this in our trial. All species tested established well and were very competitive with weeds.

For growers interested in supporting pollinators, maximizing aboveground biomass, and utilizing biofumigant crop properties for disease control, brown mustard and 'Carwoodi' radishes appear to be the best choices. The other four radish varieties, oilseed, 'Groundhog', and 'Tapmaster' produced large roots that grew deep into the soil, a feature that would help improve structure and water infiltration in compacted soils. Ultimately, all varieties were outstanding performers for biomass production and weed suppression.

Section 3: Outreach

Farm visits

Elisabeth, Lindsey, Jud, and Chuck visited farms in January–December 2021, reaching farms in all six Northern New York counties collectively with advice on brassica production and any additional vegetable production challenges identified by the growers. Farm and produce auction visits conducted:

- Elisabeth Hodgdon: 132 visits in Clinton, Essex, Franklin, Lewis, and St Lawrence counties

- Lindsey Pashow: 51 visits in Clinton, Essex, Franklin, Jefferson, and St Lawrence counties
- Jud Reid: 18 visits in Clinton, Essex, Franklin, Jefferson, Lewis, and St Lawrence counties
- Chuck Bornt: 2 visits in Clinton and Franklin counties.

NNY Grower Meetings
September 8, 2021; St Lawrence Valley Produce Auction, North Bangor, NY; 70 adults and children attended. Jud and Elisabeth presented information on major vegetable pests and diseases seen in the NNY region during the 2021 season farm visits, including important diagnostic features, biology, and management options. They included a specific overview of major brassica pests and diseases seen in Northern NY, including spread of the invasive swede midge.

October 27, 2021; Lewis County CCE classroom, Lowville, NY: 7 vegetable grower participants attended the "Extending the Season in NNY Using High Tunnels" workshop. Elisabeth and Jud presented on the use of high tunnels for season extension (see www.nnyagdev.org for past research trials reports), suggested crop rotation and varieties, and economics. Elisabeth presented results from the 2021 spring sprouting broccoli and cabbage trials and enterprise budgets.

October 5, 2021; Willsboro Research Farm, Willsboro, NY; Cover Crop Field Afternoon in collaboration with the Lake Champlain Basin Program: Twenty-three vegetable and field crops growers and agricultural service providers primarily from Essex and Franklin counties toured the NNYADP brassica cover crop field trial. Speakers included Mark Kimball of Essex Farm, who highlighted the benefits of cover crops on his farm. Alice Halloran discussing no-till seeding equipment available from the Essex County Soil and Water Conservation District, and Elisabeth and Willsboro Farm Manager Mike Davis discussed how to select cover crops species and which cover crops provide weed control. Preliminary results of the NNYADP brassica cover crop trial were presented.

Virtual workshops
Lindsey offered a series of three marketing workshops: Pricing, Finding Markets, and Market Evaluation for fruit and vegetable growers in fall 2021; recordings are available via the ENYCHP YouTube page. A total of 33 participants viewed the Pricing workshop, 18 viewed Finding Markets, and 25 viewed Market Evaluation during the live session or watched the recording.

On February 17, 2022, Elisabeth and Chuck will hold a virtual brassica workshop for vegetable growers in conjunction with the 2022 ENYCHP Winter Conference. The workshop will include results from the NNYADP sprouting broccoli and cabbage trial.

Produce Safety Alliance (PSA) Grower Training Courses
We held two PSA Grower Training Courses virtually via Zoom: October 20–21 (ten participants, three from Northern New York counties) and December 8-9 (27 participants, three from Northern New York counties). If participants required technological assistance, we offered them space at regional CCE offices (1 grower attended via Clinton County CCE office). Seven course modules were presented. A NYS Department of Agriculture, Food, and Markets representative

discussed inspections, on-farm readiness reviews, and how to write an effective farm food safety plan.

Grower Newsletter
Elisabeth shared results of the broccoli and cabbage experiment in the ENYCHP's off-season newsletter, Produce Pages, in January 2022. Results of the winter broccoli experiment will be shared in June 2022.

Acknowledgements:

We thank Andy Galimberti, Mike Davis, Natasha Field, Delvin Meseck, Adam Sayward, and Laura McDermott for their assistance with seeding, plot maintenance, data collection, and data analysis for the brassica vegetable and cover crop field experiments. Sprouting broccoli and cabbage seeds were provided free of cost by Bejo Seeds for the high tunnel experiment, courtesy of Jan van der Heide. Juniper Hill Farm provided the use of greenhouse space to start our broccoli and cabbage seedlings.

For More Information:

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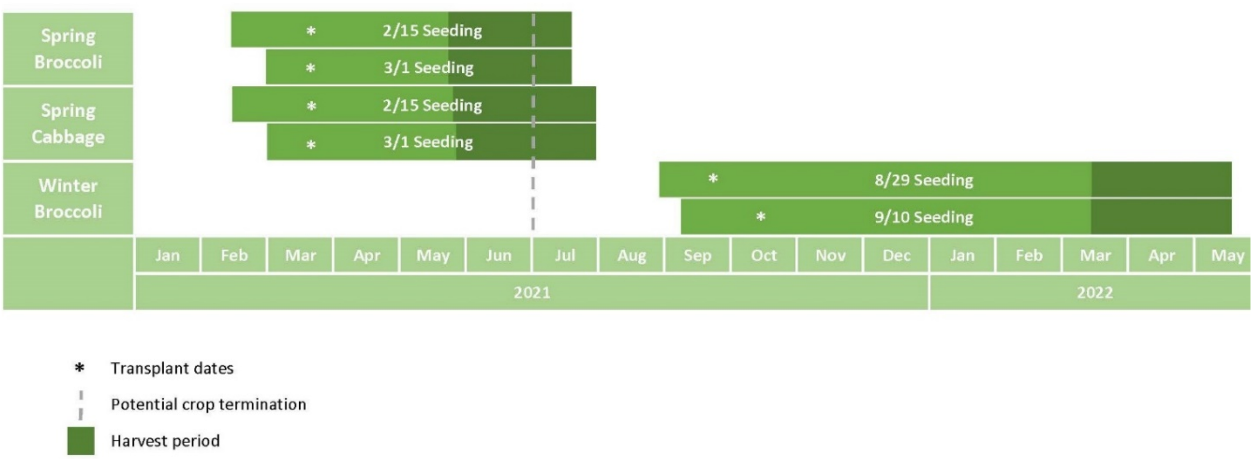
Figures:

Figure 1. Lateral shoots ("sprouts") from spring sprouting broccoli varieties (left) and main crowns of 'Burgundy' (right). NNYADP Brassica Crops Trials, 2021.
Photos: E. Hodgdon (left), A. Galimberti (right).

Figure 2a and b. Miniature spring cabbages harvested in June at a young stage. The purple variety ‘Omero,’ not pictured, produced few marketable heads. NNYADP Brassica Crops Trials, 2021. Photos: E. Hodgdon



Spring broccoli varieties: ‘Burgundy’ and ‘Montebello’
Spring cabbage varieties: ‘Caraflex,’ ‘Katarina,’ ‘Omero’ and ‘Tiara’
Winter broccoli varieties: ‘Bonarda,’ ‘Mendocino,’ and ‘Santee’

Figure 3. Sprouting broccoli and cabbage experimental timeline at Willsboro Farm, NNYADP Early Spring Brassica Crops Trials, 2021. Graphic courtesy of A. Galimberti.

Figure 4 (left) . Plots of spring sprouting broccoli (left) and cabbages (right) on April 20, 2021. NNYADP Brassica Crops Trials, 2021. Photo: E. Hodgdon.
Figure 5 (right). Winter sprouting broccoli before covering for the winter on November 22, 2021. NNYADP Brassica Crops Trials, 2021. Photo: E. Hodgdon.

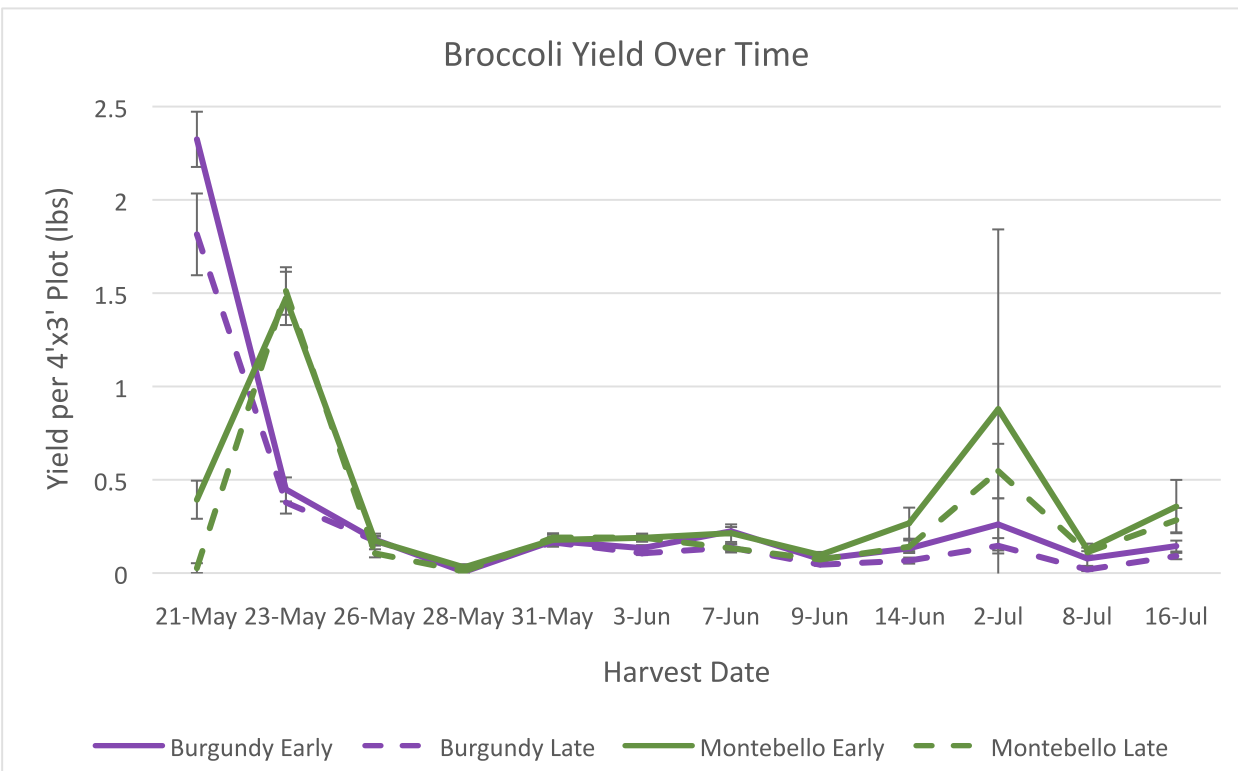


Figure 6. Sprouting broccoli harvest over time from experimental plots at Willsboro Farm. NNYADP Brassica Crops Trials, 2021.

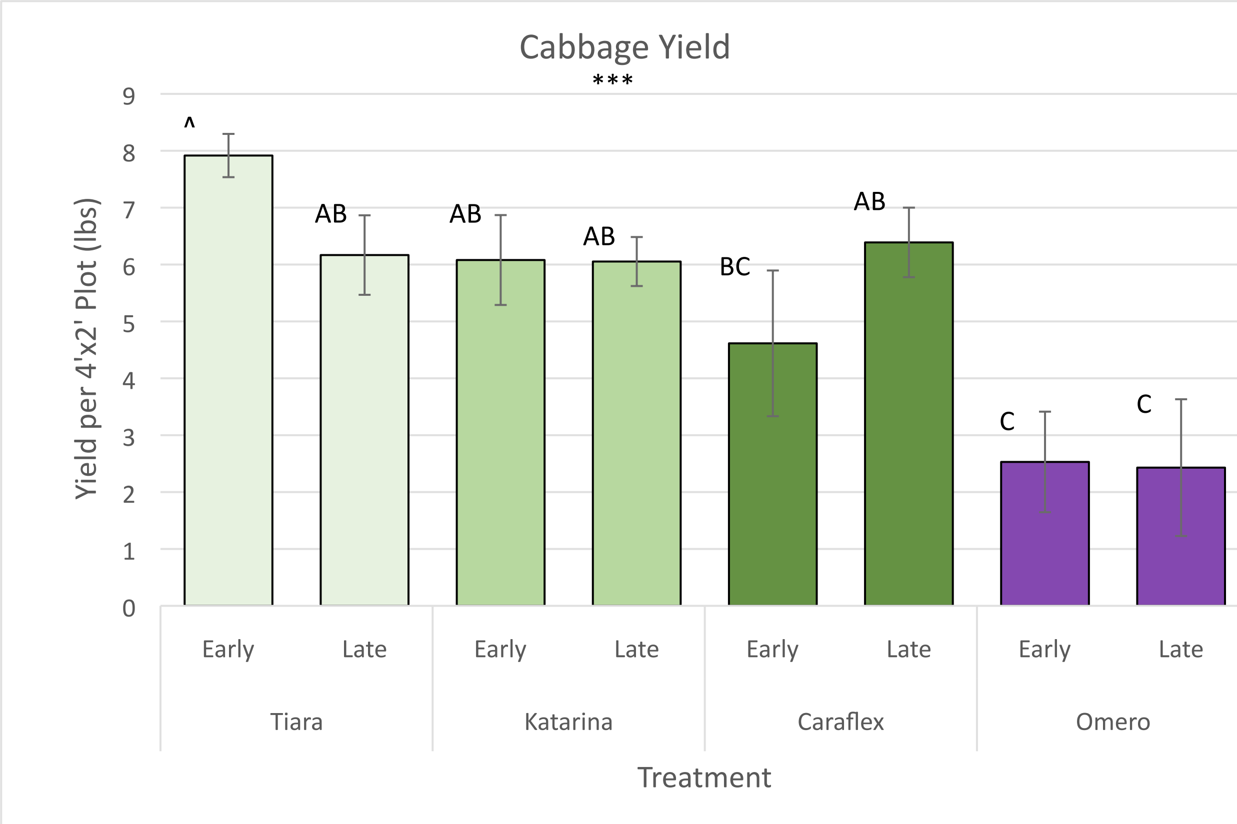


Figure 7. Total cabbage yield from 4 ft x2 ft experimental plots, where "early" refers to February 15, 2021 seeding, and "late" refers to March 1, 2021 seeding. The overall model determining effect of seeding date and variety on cabbage yield was significant, $F_{11, 28}$ = 10.3475, $p < 0.001$, as indicated by asterisks *. Treatment bars labeled with the same letters are not significantly different according to Tukey *post hoc* pairwise comparison tests ($p > 0.05$). NNYADP Brassica Crops Trials, 2021.**

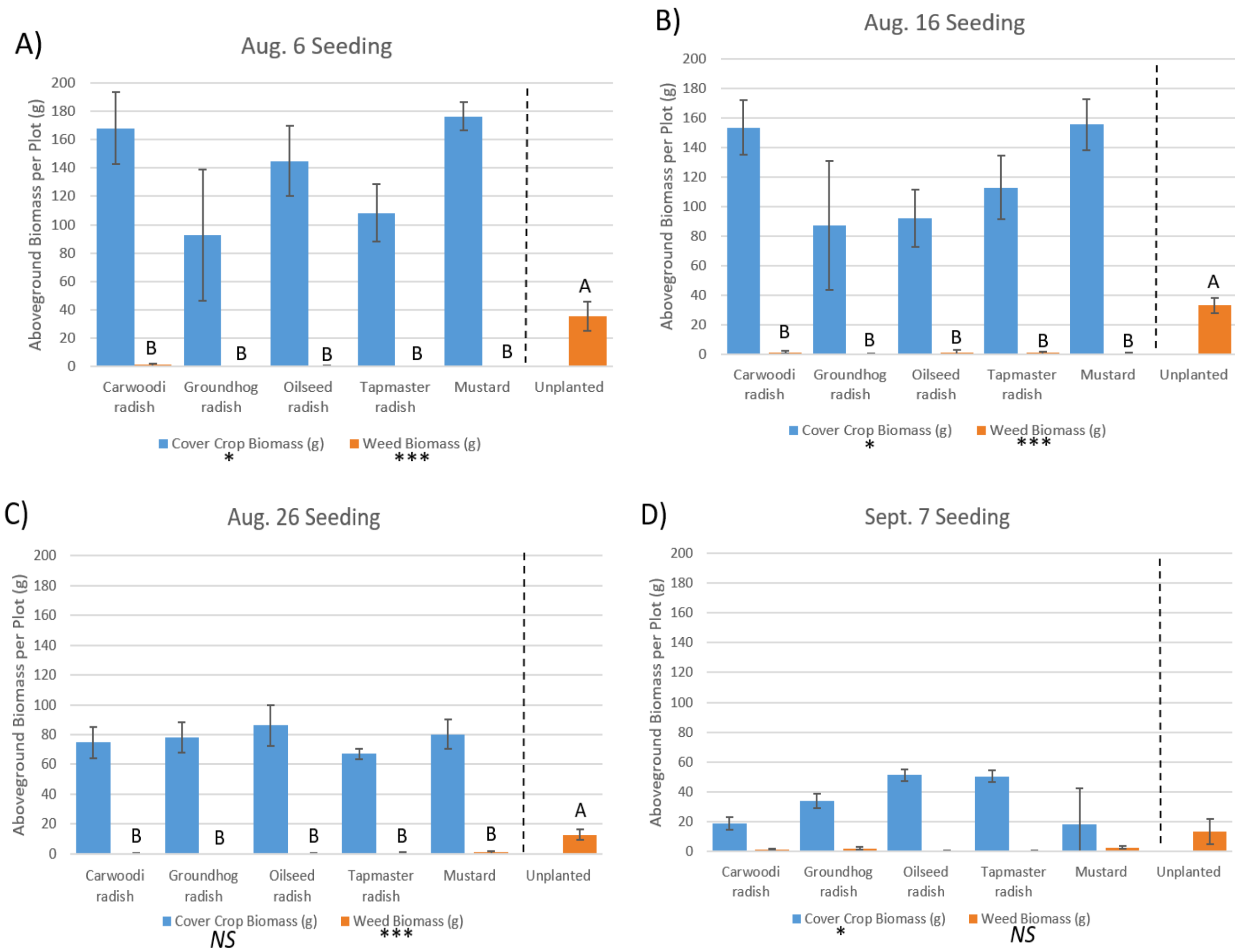


Figure 8. Aboveground dry biomass (cover crop and weeds) in plots across four seeding dates (A–D). Asterisks and letters below graphs at legend indicate significance of overall models of cover crop and weed biomass with variety as a predictor variable, where * = $p < 0.05$, *** = $p < 0.001$, and NS = non significant ($p > 0.05$). Different letters above weed biomass bars indicate that treatments are significantly different ($p < 0.05$) according to Tukey *post hoc* pairwise comparison tests. Although ANOVA models of cover crop biomass were significant in our first, second, and fourth (A, B, and D) planting date plots, no pairwise comparisons were significant. NNYADP Brassica Crops Trials, 2021.

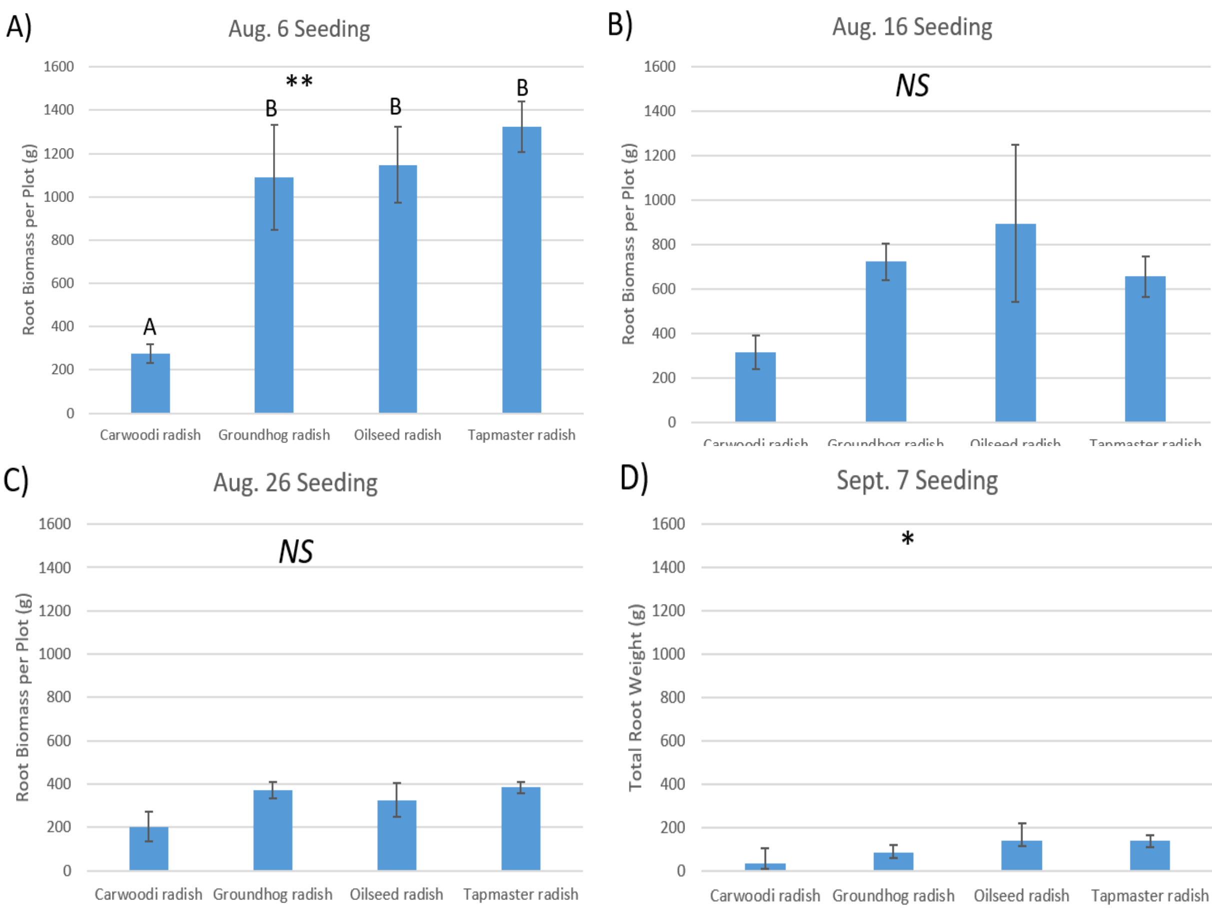


Figure 9. Radish belowground (fresh root) biomass in plots across four seeding dates (A–D). Asterisks and letters at top of graphs indicate significance of overall models with variety as a predictor variable, where * = $p < 0.05$, ** = $p < 0.01$, and NS = non significant ($p > 0.05$). Different letters above bars indicate that treatments are significantly different ($p < 0.05$) according to Tukey *post hoc* pairwise comparison tests. Although ANOVA models of root biomass were significant in fourth (D) planting date plots, no pairwise comparisons were significant. NNYADP Brassica Crops Trials, 2021.

Figure 10. Forage radish varieties on October 1, 2021 from August 6 seeding. Orange stakes (size reference) are 12" long. NNYADP Brassica Crops Trials, 2021. Photos: E. Hodgdon.

Figure 11: Plots seeded in August 2021 (above) produced significantly higher biomass than those seeded in September 2021 (below). NNYADP Brassica Crops Trials, 2021. Photos taken on October 13, 2021. Photos: A. Galimberti.

NNYADP Program 2021 Project Final Report APPENDIX

	SPRING BROCCOLI ENTERPRISE BUDGET								
			Per tunnel				Per4'x90' bed		
			Price	Qty	Units	Total cost	Total cost	Notes	
Variable costs	Bed Preparation and Transplanting	Land Preparation	15	1	hrs	15.00	3.75		
		Transplant Purchased	10	12	128-trays	120.00	30	1	
		Transplanter Labor Hour	15	1.5	hrs	22.50	5.625		
	Fertilizer and Sprays	Fertilizer (Pro Booster)	38.03	1.06	bags	40.31	10.07795	2	
		Fertilizer (Potassium Sulfa	63	0.3	bags	18.90	4.725	3	
		Fertigation	21.55	1	tub	21.55	5.3875	4	
		Fertilizer Labor	15	0.75	hrs	11.25	2.8125		
		Insecticide	25.9	0.03	lb	0.78	0.19425	5	
		Adjuvent	0.4	0.13	oz	0.05	0.0125	6	
		Spray Labor	15	0.75	hrs	11.25	2.8125		
	Irrigation	Irrigation	1440	0.14	ft	201.60	50.4	7	
	Row Cover and Hoops	Labor	15	1	hrs	15.00	3.75	8	
	General Farm Labor	Labor	15	1	hrs	15.00	3.75	9	
	Harvest	Labor	15	49.2	hrs	738.00	184.5	10	
	Total Variable Cost					**1,231.19**	**307.7972**		
Fixed Costs	General Fixed Cost	Row Cover	44	1	unit	44.00	11	11	
		Hoops	0.19	128	unit	24.32	6.08	12	
		Tractor/Machinery	17.25	1	hrs	17.25	4.3125	13	
		Land Rent	139	0.07	ac	9.73	2.4325	14	
		High Tunnel	605.33	0.33	unit	199.76	49.939725	15	
	Total Fixed Costs					**295.06**	**73.764725**		
		TOTAL COSTS				**1,526.25**	**381.561925**		
			Price/lb	**Yield**	**Unit**				
		Gross income	6	521	lbs	3,126.84	781.71	16	
Farm scenario:			8	521	lbs	4,168.00	1042		
High Tunnel size: 30'x96'		Net Income				**1,600.59**	**400.148075**	$6/lb	Aug. 1 crop
Assume 4 beds of broccoli / tunnel						**2,641.75**	**660.438075**	$8/lb	termination
Bed Size 4'x90' = 360 plants per bed		Gross Income	6	358	lbs	2,148.84	537.21	17	
Plant Density 12"x12"			8	358	lbs	2,864.00	716		
Yields from Feb. 15 seeded 'Montebello		Net Income				**680.31**	**170.078075**	$6/lb	June 15 crop
Crop terminated either Aug. 1 or June 15						**1,395.47**	**348.868075**	$8/lb	termination

Notes *(see additional notes on next page)*

1. 1,440 plugs needed
2. 50 lb bag of Pro Booster @$38.03 = $1.31/lb, need 52.8 lbs to apply rate of 80 lbs/ac
3. 50 lbs bag potassium sulfate (0-0-52) @$63/bag = $1.26/lb, need 15 lbs to apply rate of 120 lbs/ac
4. Jack's All Purpose, 4 lb tub for fertigation through drip line
5. DiPel $25.90/lb = $1.61 per oz, 6 tsp = 0.48 oz (0.03 lbs) per application
6. Nufilm $51.00 gallon (128 oz) = $0.40 / oz. Used 0.125 oz/tunnel.
7. 2 lines * 4 beds * 90U = 1,440 U. drip line. $140 for 1,000 U irrigation system ($0.14/U)
8. Installing hoops, covering plants during cold nights (-32F)
9. Weeding, rolling up and down sides, irrigation maintenance, scouting for pests, etc.
10. Multiple harvests needed (1-2 times per week)
11. Heavy Typar row cover ($110 15'x100' *2), assume 5 years use at $44/year
12. $135 ($76 for 100 hoops), hoops every 3 feet, 128 for en<re high tunnel $1.35 per hoop, with 7 years depreciation = $0.19/hoop
13. 4h @ $69 rototiller rental (Home Depot rate) to prepare soil for transplanting. Rate differs for tiller owners.
14. $139/ac/yr land rental. 2880 sq U (0.07 ac) needed for 4 mo. Rate differs for land owners.
15. $605.33 for year rental only used for 4 months
16. Used early-seeded 'Montebello' yields (highest yielding)
17. Harvest labor reduction for earlier crop termination: Less 163 lbs harvested * 0.024 h/lb = 3.85h * $15/h = $57.72

Herbicide, fungicide, and cleaning/packing costs not included in Willsboro Farm enterprise budget. Washing, packing, and marketing costs will vary by operation.

	SPRING CABBAGE ENTERPRISE BUDGET								
			Per tunnel				Per4'x90' bed		
			Price	Qty	Units	Total cost	Total cost	Notes	
Variable costs	Bed Preparation and Transplanting	Land Preparation	$15.00	1	hrs	$15.00	$3.75		
		Transplant Purchased	$10.00	23	128-trays	$230.00	$57.50	1	
		Transplanter Labor Hour	$15.00	3	hrs	$45.00	$11.25		
	Fertilizer and Sprays	Fertilizer (Pro Booster)	$38.03	0.26	bags	$9.89	$2.47	2	
		Fertilizer (Potassium Sulfat	$63.00	0.3	bags	$18.90	$4.73	3	
		Fertigation	$21.55	1	tub	$21.55	$5.39	4	
		Fertilizer Labor	$15.00	0.75	hrs	$11.25	$2.81		
		Insecticide	$25.90	0.03	lb	$0.78	$0.19	5	
		Adjuvent	$0.40	0.13	oz	$0.05	$0.01	6	
		Spray Labor	$15.00	0.75	hrs	$11.25	$2.81		
	Irrigation	Irrigation	$1,440.00	0.14	ft	$201.60	$50.40	7	
	Row Cover and Hoops	Labor	$15.00	1	hrs	$15.00	$3.75	8	
	General Farm Labor	Labor	$15.00	1	hrs	$15.00	$3.75	9	
	Harvest	Labor	$15.00	49.2	hrs	$738.00	$184.50	10	
	Total Variable Cost	[redacted]				**$1,333.26**	**$333.32**		
Fixed Costs	General Fixed Cost	Row Cover	$44.00	1	unit	$44.00	$11.00	11	
		Hoops	$0.19	128	unit	$24.32	$6.08	12	
		Tractor/Machinery	$17.25	1	hrs	$17.25	$4.31	13	
		Land Rent	$139.00	0.07	ac	$9.73	$2.43	14	
		High Tunnel	$605.33	0.33	unit	$199.76	$49.94	15	
	Total Fixed Costs	[redacted]				$295.06	$73.76		
		TOTAL COSTS				**$1,628.32**	$407.08		
			Price/lb	**Yield**	**Unit**				
		Gross Income	4	1424	lbs	$5,696.00	$1,424.00	16	
Farm scenario:			6	1424	lbs	$8,544.00	$2,136.00		
High Tunnel size: 30'x96'		Net Income				**$4,067.68**	$1,016.92	$4/lb	Aug. 1
Assume 4 beds of cabbage / tunnel						**$6,915.68**	$1,728.92	$6/lb	crop termination
Bed Size 4'x90' = 360 plants per bed		Gross Income	4	1173	lbs	4,692.00	$1,173.00	17	
Plant Density 6"x12"			6	1173	lbs	7,038.00	$1,759.50		
Yields from Feb. 15-seeded 'Tiara'		Net Income				**3,125.02**	$781.25	$4/lb	Jun. 24
Crop terminated either Aug. 1 or Jun. 24						**5,471.02**	$1,367.75	$6/lb	crop termination

Notes (*see additional notes on next page*)

1. 2,880 plugs needed
2. 50 lb bag of Pro Booster @$38.03 = $1.31/lb, need 13 lbs to apply rate of 20 lbs/ac
3. 50 lbs bag potassium sulfate (0-0-52) @$63/bag = $1.26/lb, need 15 lbs to apply rate of 120 lbs/ac
4. Jack's All Purpose, 4 lb tub for fertigation through drip line
5. DiPel $25.90/lb = $1.61 per oz, 6 tsp = 0.48 oz (0.03 lbs) per application
6. Nufilm $51.00 gallon (128 oz) = $0.40 / oz. Used 0.125 oz/tunnel.
7. 2 lines * 4 beds * 90W = 1,440 W. drip line. $140 for 1,000 W irrigation system ($0.14/W)
8. Installing hoops, covering plants during cold nights (-32F)
9. Weeding, rolling up and down sides, irrigation maintenance, scouting for pests, etc.
10. Multiple harvests needed (1-2 times per week)
11. Heavy Typar row cover ($110 15'x100' *2), assume 5 years use at $44/year
12. $135 ($76 for 100 hoops), hoops every 3 feet, 128 for en<re high tunnel $1.35 per hoop, with 7 years depreciation = $0.19/hoop
13. 4h @ $69 rototiller rental (Home Depot rate) to prepare soil for transplanting. Rate differs for tiller owners.
14. $139/ac/yr land rental. 2880 sq W (0.07 ac) needed for 4 mo. Rate differs for land owners.
15. $605.33 for year rental only used for 4 months

16. Used early-seeded 'Tiara' yields (highest yielding)
17. Harvest labor reduction for earlier crop termination: Less 251 lbs harvested * 0.016 h/lb = 4.1h * $15/h = $61.34

Herbicide, fungicide, and cleaning/packing costs not included in Willsboro Farm enterprise budget. Washing, packing, and marketing costs will vary by operation.

Winter Spinach Comparison

Winter Spinach* Comparison		Yield (lbs/sq ft)	Yield (4'x90' bed)	Gross income 1 bed	Gross income tunnel
Essex/Washington Co/Jan 2022	2019-20	0.76	273.6	3830.4	15321.6
*Prices	2020-21	0.91	327.6	4586.4	18345.6
Farm A: $7/half lb bag ($14/lb)					
Farm B: $4/0.29 lb bag; $6.89/half lb ($13.78/lb)					
		Yield 2-year avg	Gross income		
Best-yielding treatments:		Per tunnel	$13/lb	$15/lb	
2019-20 PB 130		1202.4	15631.2	18036	
2020-21 PB 65		Per bed			
			3907.8	4509	

Figure 14. Vegetable and field crops growers discuss their strategies for using cover crops at the Willsboro Cover Crop Field Afternoon on October 5, 2021. Photo: E. Hodgdon