Broccoli (*Brassica oleracea*) var. 'Green Magic'
Spinach (*Spinacia oleracea*) var. 'Marabu RZ'

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"Tarping" for no-till cover crop management in small-scale specialty crops

Specialty crop production generally relies on preplant tillage to prepare a level, smooth seedbed for planting. This springtime tillage can cause loss of soil structure and stimulate weed germination. No-till is not widely used in specialty crop production because of concern about residue from the previous crop interfering with planting, the difficulty of smaller planters to get proper crop establishment, and cooler soil temperatures. This research was designed to address these issues with seedbed preparation in the fall, followed by cover cropping, tarping and planting into a weed-free seedbed in the spring. All equipment was either manual equipment or compatible with a small tractor (35 to 40 horsepower).

The trial was conducted in 2021 and 2022 at the University of DE Research & Education Center. Two fall tillage practices were evaluated. One, moldboard plowing which buries recently deposited weed seeds too deep to emerge, followed by seeding a cereal rye cover crop. The second practice was fall rototilling, which was used to disturb the soil layer to a 3 to 4-inch depth followed by seeding cereal rye. In addition, fall cover cropping with a spring tillage using rotary till as well as no fall cover cropping and spring rotary till was also evaluated. The experiment was conducted as a randomized complete block design with four replications. Treatments simplified:

1. Fall moldboard plow, fall cover crop, spring tarping, plant no-till
2. Fall rotary till, fall cover crop, spring tarping, plant no-till
3. Light disking, fall cover crop, spring rotary till, plant conventional
4. No fall treatments, no cover crop, spring rotary till, plant conventional

Tillage was completed with a 2-bottom plow followed by a small disc or a tractor-mounted rototiller and ground was worked twice. Cereal rye was seeded with a drill at 60 lb/A. Mid-March rye biomass samples were taken from tarp treatment and tarps were placed over the respective rye cover crop treatment and secured (Photo 1). Tarps were silage bunker covers (6 mls thick with one side white and other side black). A single tarp was used to cover each plot and black side was placed up. In 2021, tarps were installed on March 24 and removed 3 weeks later; in 2022, the tarps were laid March 15 and removed 4 weeks after placement (Photo 2). Rye biomass was taken in the no-tarp cover crop treatment at time of tarp removal. Spring rototilling (twice) was used to kill/incorporate rye and winter weeds in plots without tarping.

In April immediately following tarp removal or rotary till, spinach was seeded at approximately 10 seeds/ft (14 lb/A) in 5-row beds on 12-inch spacing using a push planter (Jang JP1® roller seeder). Broccoli transplants were hand planted at 1 per foot in 3-row beds on 36-inch row spacing. A hand-pushed, single wheel planter (Tilmor® mulch planter) was used to create 2-inch-deep plug holes on 12 inch spacing for ease of transplant. Fertilizer was applied at the recommended rates for each crop regardless of tillage system. Overhead irrigation was used as needed.

Over the growing season, vegetable crops were evaluated for stand, visual crop vigor (rated 0 for plant death to 100 for largest/healthiest plants) and harvested at maturity. Data collection also included weed counts (by species), and timed hoeing and hand-weeding of an area 5 ft wide by 20 ft long. Soil samples were taken and analyzed for nutrients, organic matter, and active carbon. Soil moisture and soil temperature sensors (Teros11® sensors) were installed under plastic tarp in the fall rotary tilled with cover crop plots and in the treatment with no fall tillage and no cover crop for comparison.

Results and Discussion:

Table 1. Rye biomass dry weights (grams/m^2) and collection dates. In 2021 chicken litter was added to field which increased rye biomass. No soil amendments were added prior to cover crop planting in 2020. Some rye did survive and reestablish both years.

Fall tillage	Rye cover crop	Spring cover termination	Spring tillage	2021 Cereal rye dry weight (grams/m^2 - lbs/A)	2021 Date rye biomass taken	2022 Cereal rye dry weight (grams/m^2 – lbs/A)	2022 Date rye biomass taken
moldboard plow	yes	tarp	no-till	28 (250)	March 22	191 (1704)	March 14
rotary till	yes	tarp	no-till	25 (223)	March 22	143 (1276)	March 14
light disking	yes	rotary till	rotary till	58 (517)	April 12	193 (1722)	April 11
none	no	--	rotary till	no cover		no cover	

Table 2. Broccoli results: transplanting success, plant vigor and yield. Transplanting in the firmer no-till treatment required slightly more effort due to moving the soil to cover the root ball but did not add much time to planting (photos 3&4). In 2021, broccoli in the moldboard plow treatment showed less vigor and had lower yields compared to all other treatments. The reduced yield was likely due to lower boron levels than other treatments (AgroLab soil test results, data not presented). In 2022, moldboard plow treatment showed greater vigor and had better yields at the first harvest than all other treatments (data not presented). However, total yield for the season did not differ between treatments. (See photos 5-8).

Fall tillage	Rye cover crop	Spring cover termination	Spring tillage	2021 Plant vigor (%) 6 WAP[1]	2021 Yield # heads (total 3 harvests	2022 Plant vigor (%) 5 WAP	2022 Yield # heads (total 2 harvests
moldboard plow	yes	tarp	no-till	56 b[y]	37 b	99 a	39
rotary till	yes	tarp	no-till	83 a	42 a	78 b	32
light disking	yes	rotary till	tillage	78 a	41 a	64 c	24
none	no	rotary till	tillage	76 a	43 a	62 c	31
P[x]*>F*				0.0455	0.0206	0.0001	NS

[1] WAP = weeks after planting.

[y] Means within a column followed by the same letter are not significantly different (p=0.05) according to Fisher's protected LSD test.

[x] P values ≤0.05 indicate significant differences exist among treatments.

Table 3. Spinach results: stand counts, plant vigor and 2021 yield. Spinach stands were higher both years in the no-till treatments (comparison photos 9 & 10). Over the 2-year trial, the fall rotary till/tarping/no-till strategy consistently had better stands, with greater vigor and yield. Lower yields with fall moldboard plow was likely due to lower organic carbon than other treatments (AgroLab soil test results, data not presented). Spinach was not harvested in 2022 due to heavy seed corn maggot feeding in residue-incorporated treatments.

Fall tillage	Rye cover crop	Spring cover termination	Spring tillage	2021 Stand cnts # plants/5 ft-row 4 WAP[1]	2021 Plant vigor (%) 6 WAP	2021 Yield weight lbs (single harvest)	2022 Stand cnts # plants/5 ft-row 4 WAP	2022 Plant vigor (%) 4 WAP
moldboard plow	yes	tarp	no-till	58 a[y]	43 c	0.55 b	62 a	84 a
rotary till	yes	tarp	no-till	58 a	88 a	1.46 a	60 a	83 a
light disking	yes	rotary till	tillage	28 b	72 b	1.09 ab	12 b	20 b
none	no	rotary till	tillage	14 c	75 b	0.94 ab	3 b	8 b
P[x]>F				0.0001	0.0002	0.0488	0.0012	0.0005

[1] WAP = weeks after planting.

[y] Means within a column followed by the same letter are not significantly different (p=0.05) according to Fisher's protected LSD test.

[x] P values ≤0.05 indicate significant differences exist among treatments.

Table 4. Weed assessment. Weeds were counted by species 5 weeks after planting. Volunteer rye was a significant weed in no-till plots both years (data not presented). In 2021 use of moldboard plow significantly decreased pigweed specie emergence. In 2022 all cover crop treatments had significantly less yellow nutsedge as compared to the no cover treatment. Cumulative weed densities (sum of all species excluding volunteer cereal rye) did not differ between treatments in either year. In 2021 hand weeding was more time consuming in the fall rotary till plots due to cereal rye reestablishment and rapid growth. No significant timed-weeding differences were noted in 2022.

Fall tillage	Rye cover crop	Spring cover termination	Planting	2021 Pigweed density (#/m^2) 5 WAP[1]	2021 Summer annual weed density (#/m2) 6 WAP	2021 Timed weeding (minutes) 6 WAP	2022 Yellow nutsedge (#/m^2) 5 WAP	2022 Summer annual weed density (#/m2) 6 WAP	2022 Timed weeding (minutes) 6 WAP
moldboard plow	yes	tarp	no-till	1 b[y]	13	10 b	3 b	8	7
rotary till	yes	tarp	no-till	6 a	19	16 a	4 b	11	8
light disking	yes	rotary till	tillage	5 a	22	9 b	9 b	17	8
none	no	rotary till	tillage	5 a	27	12 b	23 a	28	10
P[x]>F				0.0448	NS	0.0147	0.0275	NS	NS

[1] WAP = weeks after planting.
[y] Means within a column followed by the same letter are not significantly different (p=0.05) according to Fisher's protected LSD test.
[x] P values ≤0.05 indicate significant differences exist among treatments.

Summary.

- Although previous research at Cornell University[1] has shown that 3 week-tarping was sufficient to kill cereal rye, this research shows more than 4 weeks is needed to achieve 100% control of cereal rye. A small percentage of rye survived, regrew, and became weeds.
- Soil temperature under tarps (sensor at a 2-inch depth) averaged 1 degree warmer compared to open, no cover plots. Soil temperatures after tarp removal varied only 1-2 degrees with warmer temperatures in the conventionally tilled soil (data not presented).
- Vegetable crop seeding/transplanting was achievable with push planters, regardless of tillage.
- Overall weed densities (excluding volunteer cereal rye) did not differ between treatments either year. Hand weeding was more time consuming in the fall rotary tilled tarp treatment in 2021 due to rye reestablishment and difficulty removing.
- Soil active carbon differed between treatments in 2021 only. Active carbon readings were lower in moldboard plow treatment compared to fall rotary till and no cover treatment (data not presented).
- Broccoli yield showed contrasting results between the two years. In 2021 yield was reduced in the moldboard plow treatment. In 2022, the moldboard plow treatment matured faster than other treatments resulting in a higher yield at the first harvest. However, 2022 total yield did not differ between treatments.
- Spinach yield was greater in fall rotary till, tarped no-till treatment as compared to the moldboard plow (single years data).

Considerations:

We anticipated the fall cover cropping and using tarps to kill the rye would:

- increase soil temperatures
- reduce weed levels in the plots
- improve early-season vigor of the crops, and
- lead to earlier harvests

The tarps for this trial did not sit completely flat and air pockets formed. This may account for why soil temperatures did not rise as much as anticipated. Some researchers mowed the cover crop with a flail mower prior to tarping in order to increase the contact of the tarps with the soil surface.

Since soil temperatures did not increase, we did not see a reduction in weed densities. Likewise, differences in early-season vigor cannot be explained by soil temperature since they were not consistent for both years.

Seed corn maggots were found in residue-incorporated plots. Incorporation of organic matter adds a risk for seed corn maggot activity. In order to lessen the chance of seed/seedling feeding, farmers might consider using an insecticide-treated seed or broadcast application prior to planting.

Additional research should also focus on crop fertility under these different tillage systems.

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Works cited:

[1] Lounsbury, N., University of New Hampshire; S. Birthisel and J. Lilley, University of Maine; R. Maher, Cornell University. “Tarping in the Northeast: Tarping Practices.” Bulletin #1075. https://extension.umaine.edu/publications/1075e/practices/#rotational-no-till

Photo 1. Cereal rye plot covered by heavy duty, reusable tarp and sandbags.

Photo 2. 2022. Tarps were removed in mid-April, 4 weeks after installation. Rye severely injured but still alive.

Photos 3 & 4. Broccoli planted in conventionally tilled (top) and no-till (bottom) treatments. Although planting in the firmer no-till treatment required slightly more effort to move the soil and cover the root ball, it did not add much time to planting.

Photos 5 to 8. Broccoli plots in 2022, 3 weeks after planting (left). Broccoli in spring rototilled (top) and no-till (bottom). Broccoli vigor was better in no-till treatments. Photos at 6 weeks after planting (right). Broccoli vigor remained greater in no-till treatments. At yield, the moldboard plow, no-till treatment matured earliest, followed by the fall rotary-till-no-till treatment. In the conventionally tilled plots broccoli maturity/head formation was delayed by 7-10 days. (Photos on the right taken after hand-weeding)

Top and bottom photos taken 3 weeks after planting	**Top and bottom photos taken 6 weeks after planting**
	
	

Photos 9 & 10. 2021, 3 weeks after planting. Spinach seeded in conventionally tilled (top) and no-till (bottom) ground with a push planter/roller-seeder. Spinach emergence and early establishment was attainable in both tillage systems. Due to incomplete termination of the cover crop with the tarping systems, cereal rye cover became a weed in no-till treatments. Spinach stands were reduced in the residue-incorporated treatments due to seed corn maggot feeding.