COVER CROPS IN ORGANIC VEGETABLE SYSTEMS

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OVERVIEW

• What’s the Problem?
• Ways Covers Can Be Used In Vegetable Systems
• Key Issues Cover Crops Can Address
• Termination Strategies
• Documented Benefits
• Resources for Beginning and Advanced Cover Crop Adopters
What’s the Problem?

Per capita consumption of fruits and veg. = 632 lbs/yr

Organic imports exceed exports by a margin of 3:1.

Celery harvest in Florida. Date Unknown. Univ. FL Library Archives
Water Quality and Quantity Risks in Florida
Water Quality and Quality Risks in California

[Map of California with groundwater level changes]

Addressing Nitrate in California’s Drinking Water
With a Focus on Tulare Lake Basin and Salinas Valley Groundwater

Report for the State Water Resources Control Board Report to the Legislature

Prepared for the California State Water Resources Control Board


Community Public and State Small Water Systems, Raw Water Nitrate Levels, 2006-2010 (mg/L)

- up to 1.0
- 1.0 - 15
- 15.1 - 22.6
- 22.6 - 45
- 45.1 - 90
- over 90

[Map of California with nitrate levels]

http://www.water.ca.gov/waterconditions/docs/DOTMAP_F1511_100.pdf
USES OF COVER CROPS IN VEGETABLE SYSTEMS

- In field perimeters:
  - a trap crop or
  - habitat for beneficial insects

- In furrows:
  - a wind break,
  - acquire soil nutrients,
  - remove/retain moisture

- In rotation:
  - reduce weed seed deposition
  - reduce nematodes
  - add organic matter
  - cycle nutrients
  - manage soil moisture
Stink bugs (Pentatomidae) and leaf footed bugs (Coreidae) are important pests of many fruit and vegetable crops.

‘Giganteus’ sunflower with yellow pyramid traps effective in reducing Leaf footed stink bug. Russ Mizzell, UF-IFAS

Triticale with crimson clover and vetch, sorghum, millet, buckwheat, and sunflower are the main species recommended to attract the native stink bug species found in the Southeastern U.S.

Primary insect pest of blueberries for the Rooney's was stink bug.

A trap crop of triticale and buckwheat was planted in field perimeters.

The stink bug, *Piezodorus guildinii* was relatively abundant in the buckwheat, and was attacked by an orange tachinid fly.

Insecticides were still needed, but were only applied to the trap crop, thus eliminating the need to apply insecticides to the blueberry crop.

Blueberry growers Scott and Billie Rooney, Wellborn, FL.
Cover Crops in CA Furrows

- In conventional systems, herbicide is used to terminate covers in furrows prior to vegetable planting.
- In organic systems, plant a succulent cover such as mustard or buckwheat and terminate by cultivation or plant a species that will winter/summer kill naturally.

E. Brennan, 2017. Can we grow organic or conventional vegetables sustainably without cover crops? HortTechnology (27) 151-161
CRITERIA FOR DESIGNING ROTATIONS

• Identify time period in your system when you have the ability to seed, manage, and terminate a cover crop.
• Verify you have the equipment to manage the crop.
• Identify one primary objective.
• Review the list of recommended cover crop species in your area from NRCS, University, or other evidenced-based recommendation source.
• Evaluate the possible interactions of cover crop and subsequent vegetable crops and eliminate potential bad actors.
• Develop a back up plan.
SARE Cover Crop Innovator Series – You Tube

Buckwheat -> Broccoli
(Eastern Pennsylvania, T. Bjorkman, Cornell Univ.)

Pearl Millet + Sunn hemp -> Cabbage
(Florida, D. Treadwell, L. Zotarelli, P. Ditmar, UF)

Southern Pea -> Lettuce
(Kruse and Nair, Iowa Univ.)
Cover crops are documented to reduce nematode density but are highly dependent on cover crop cultivar and nematode species.

- Legion nematodes < French marigold, pearl millet (‘HGM 100’)
- Root-knot nematodes < grasses
- American dagger nematode < Rapeseed ‘Dwarf Essex’

Mechanism for nematode suppression is unknown, but likely root exudates create an unfavorable environment for pathogenic nematodes, or a beneficial environment for beneficial nematodes.

Faunal profile (Ferris) at UF-IFAS Organic Unit in Live Oak, FL. Soil ecosystem is enriched but disturbed. Z. Grabau et al., 2017.
<table>
<thead>
<tr>
<th>Family</th>
<th>Weed</th>
<th>Pathogen</th>
<th>Crops affected</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brassicaceae</td>
<td>Wild radish (Raphanus raphanistrum)</td>
<td>Beet western yellows virus (Polerovirus)</td>
<td>Broccoli, cauliflower, radish, and turnip (also beet, lettuce, spinach, and pea)</td>
<td>Zitter and Provvidenti 1984</td>
</tr>
<tr>
<td>Cucurbitaceae</td>
<td>Wild cucurbits (Cucumis spp.)</td>
<td>Cucumber mosaic virus (Cucumovirus)</td>
<td>Cantaloupe, cucumber, pumpkin, and squash (also bell pepper, celery, spinach, tomato, and watercress)</td>
<td>Goyal et al. 2012</td>
</tr>
<tr>
<td></td>
<td>Creeping cucumber (Melothria pendula)</td>
<td>Papaya ringspot virus type W, Zucchini yellow mosaic virus (both aphid-transmitted Potyviruses)</td>
<td>Cantaloupe, squash, watermelon</td>
<td>Kucharek and Purcifull, 2001</td>
</tr>
<tr>
<td>Fabaceae</td>
<td>Kudzu (Pueraria mont ana var. lobata), Florida beggarweed (Desmodium tortuosum), Clover (Trifolium spp.)</td>
<td>Soybean rust, Phakopsora pachyrhizi and P. meibomiae (Basidiomycota: Pucciniomycotina)</td>
<td>Soybean, common bean, garden and field peas</td>
<td>Rupe and Sconyers 2008</td>
</tr>
<tr>
<td>Poaceae</td>
<td>Johnsongrass (Sorghum halepense)</td>
<td>Maize dwarf mosaic virus A (aphid-transmitted Potyvirus)</td>
<td>Corn</td>
<td>Gatton 2015</td>
</tr>
<tr>
<td>Solanaceae</td>
<td>Jimsonweed (Datura stramonium)</td>
<td>Tomato mosaic virus (Tobamovirus)</td>
<td>Pepper, tomato</td>
<td>Alemu et al. 2002</td>
</tr>
</tbody>
</table>
• **Cover Crop Incorporated**
  • The most flexible
  • Can be followed by plastic mulch
  • Requires the most tillage for total incorporation
  • Forced into a fallow period of 2-3 weeks as you incorporate
  • Incomplete incorporation can result in volunteer cover crop and residual crowns and stems that can interfere with planters.
  • Can delay vegetable establishment

• **Cover Crop on the Surface**
  • Difficult to cultivate if weeds emerge
  • Benefits more fully realized with 5,000 lbs or more dry matter, and low lignin content crops will decompose quickly
  • Impart stability to the system under temperature and moisture variability
  • Must fully terminate, sometimes regrowth occurs
  • Can delay vegetable establishment
Ron Morse, 1990. HortTechnology

No-till Vegetable Production—Its Time is Now

Ronald D. Morse

Additional Uses: conservation tillage, residue management, high residue

Summary: Advantages of no-till (NT) production systems are acknowledged throughout the world. During the 1980s, production of NT vegetable crops increased for both direct seeded and transplanted crops. Investment in modified tillage systems among small-scale vegetable growers has led to increased use of NT, and positive perception and acceptance have been established. This is due in large part to: 1) advancements in computer technology, including the use of high-end monitors and software, 2) advancements in the technology and practice of producing and managing high-end vegetable crops, and 3) increased awareness and acceptance of integrated weed management technologies. Results from on-farm experiments and grower’s fields over the past 10 years has shown that success with NT transplanted crops is highly dependent on achieving key production objectives, including: 1) production of clean, uniformly distributed cover crops, 2) selection of cover crops before transplanting, allowing a heavy, uniformly distributed mulch cover over the soil surface, 3) establishment of transplants into cover crops with minimum disturbance of surface residue and surface soil, and 4) adoption of proper wind control strategies.

Benefits of conservation tillage in general and no-tillage (NT) systems in particular are well documented for many agronomic crops such as field corn (Zea mays L.), soybean (Glycine max (L.) Merr., L.) and cotton (Gossypium hirsutum L.) (Carret, 1994; Croxson, 1981; Griffith et al., 1986; Lal et al., 1990). Adoption of conservation tillage systems is increasing in North and South America to the extent that it now constitutes the normal or conventional method of crop production for field corn and soybean in some areas (Hebblethwaite, 1997).

Evolution of conservation in the United States

A major change in tillage practices has required a long transition period because the change involved development and adaptation of new types of equipment and methodology as well as different ways of perceiving the soil ecosystem (Brussard and Ferreira-Cerrato, 1997). In the early 1980s, moldboard plowing, excessive secondary tillage operations, and multiple cultivations led to serious erosion problems which led to serious flooding and dust storms (Phillips and Phillips, 1984). In 1943, Edward Faulkner boldly challenged the validity and wisdom of using the moldboard plow (Faulkner, 1947). Faulkner asserted: "The truth is that no one has ever advanced a scientific reason for plowing. The entire body of reasoning about the management of the soil has been based upon the axiomatic assumption of the correctness of plowing.

Table 1. Feasibility of achieving successful production of vegetable crops, using no-till production systems.

<table>
<thead>
<tr>
<th>Vegetable crop</th>
<th>Botanical name</th>
<th>Common name</th>
<th>Planting method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zea mays L.</td>
<td>Sweet corn</td>
<td>High</td>
<td>NA</td>
</tr>
<tr>
<td>Phaseolus sp.</td>
<td>Snap bean, lima bean</td>
<td>High</td>
<td>NA</td>
</tr>
<tr>
<td>Brassica sp.</td>
<td>Cabbage, broccoli, cauliflower, collard</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Cucurbita sp.</td>
<td>Pumpkin, summer squash, winter squash, gourds</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Cucumis sp.</td>
<td>Melon, muskmelon, honeydew melon, cucumber</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Citrullus lanatus Thumb.</td>
<td>Watermelon</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Capsicum annuum L.</td>
<td>Bell pepper, cayenne pepper</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Lycopersicon esculentum Mill.</td>
<td>Tomato</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Solanum tuberosum L.</td>
<td>Potato</td>
<td>Moderate</td>
<td>NA</td>
</tr>
<tr>
<td>Ipomoea batatas L.</td>
<td>Sweetpotato</td>
<td>NA</td>
<td>Moderate</td>
</tr>
</tbody>
</table>

Feasibility based on past and current observations in research plots and grower fields. In many cases, grower experience has been limited to small-scale [<25 acres (11 ha)] fields. Feasibility ratings: high = broad-scale success achieved by both researchers and growers; moderate = experience limited mainly to small-scale research plots; low = not currently recommended because of insufficient research and/or grower experiences; NA = not applicable because planting method is not commonly practiced.

1 No-till includes strip-till systems.

2 For potato, whole seed tubers or cut seed tuber pieces are planted.
Seeding Strategies - Modify Existing Equipment

Great Plains 3P605 NT Drill with raised drive wheels
Termination Methods

Mowing with rotary mowers, flail mowers, stalk choppers have very different outcomes.
Termination Methods
• Kornecki (USDA-ARS) assisted grower Frank Randle (AL) develop a cover crop management plan.
• Primary objective was weed control.
• Winter cover of crimson clover and rye to okra, tomatoes, or squash.
• First four years, tillage was needed to control weeds, but after that reduced tillage was adopted. Yields increased.

The 2-year study was conducted at the UF-IFAS Organic Unit in Live Oak, FL.

Objective: Identify mulching system that reduced weed density and maintained yield.

Four treatments arranged in a RCBD, then split to two levels of weeding intensity (high and low) six weeks after planting to evaluate the effectiveness of weed management among treatments.
Treatments

Four Mulch Treatments:
1. **ROLLER-CRIMPER:** Sunn hemp terminated by crimper, residue remains on soil surface
2. **NO MULCH:** Sunn hemp mowed and soil incorporated
3. **PLASTIC:** Sunn hemp mowed and soil incorporated, Plastic mulch 122 cm wide, 1.5 ml thickness, white on black applied
4. **CUT-N-CARRY:** Sunn hemp residue mowed and soil incorporated, rye straw applied to surface.

Two Weed Removal Frequencies:
- Each plot was divided in half perpendicular to tractor direction, and weeding treatments were randomly assigned to each plot six weeks after planting (WAP).
1. **LOW INTENSITY** weeding (every 3rd weeks)
2. **HIGH INTENSITY** weeding (every week)
## Organic Jalapeno Pepper Yield

*(Capsicum annum L. ‘Tormenta’)*

Values followed by different letters differ (p<0.05) according to a least significant range separation.

<table>
<thead>
<tr>
<th>MANAGEMENT</th>
<th>Marketable Yield 2013</th>
<th>Marketable Yield 2014</th>
<th>Total Yield 2013</th>
<th>Total Yield 2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mulch System</td>
<td>kg ha(^{-1})</td>
<td>kg ha(^{-1})</td>
<td>kg ha(^{-1})</td>
<td>kg ha(^{-1})</td>
</tr>
<tr>
<td>Roller-Crimped Sunn Hemp</td>
<td>16,061 (^b)</td>
<td>9,071 (^b)</td>
<td>20,512</td>
<td>9,121 (^b)</td>
</tr>
<tr>
<td>Cut and Carry Rye Straw</td>
<td>22,706 (^a)</td>
<td>9,856 (^ab)</td>
<td>23,845</td>
<td>9,945 (^ab)</td>
</tr>
<tr>
<td>Plastic Mulch</td>
<td>15,008 (^b)</td>
<td>10,834 (^a)</td>
<td>19,056</td>
<td>10,937 (^a)</td>
</tr>
<tr>
<td>No Mulch</td>
<td>16,794 (^b)</td>
<td>7,074 (^c)</td>
<td>18,611</td>
<td>7,121 (^c)</td>
</tr>
<tr>
<td><strong>P = 0.0063</strong></td>
<td><strong>P = 0.0005</strong></td>
<td><strong>P = 0.2296</strong></td>
<td><strong>P = 0.0004</strong></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Weeding Frequency</th>
<th>kg ha(^{-1})</th>
<th>kg ha(^{-1})</th>
<th>kg ha(^{-1})</th>
<th>kg ha(^{-1})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weekly</td>
<td>18,241</td>
<td>9,748</td>
<td>21,478</td>
<td>9,817</td>
</tr>
<tr>
<td>Every Third Week</td>
<td>17,044</td>
<td>8,669</td>
<td>19,535</td>
<td>8,745</td>
</tr>
<tr>
<td><strong>P = 0.4350</strong></td>
<td><strong>P = 0.6024</strong></td>
<td><strong>P = 0.3189</strong></td>
<td><strong>P = 0.0612</strong></td>
<td></td>
</tr>
</tbody>
</table>
Crop productivity can be stabilized in variable weather due in part to buffering capacity of surface mulch (rye straw)

The frequency of weeding did not influence pepper yield, fewer weeding events will be economically beneficial

RT Sunhemp had fewer weeds early in the season, but Cut and Carry mulch had fewer weeds later in the season.

Future research investigate additional crops and include more environmental data.
SUMMARY

• Change is constant
• Change costs money
• Process is something
• People are everything
• Decision to change occurs years before actual change can be measured
• If you build it, and build it well, measurable, beneficial changes will come