Lessons Learned in Conservation Tillage Vegetable Systems in the Sub-Tropics and Tropics

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INTRODUCTION

Conventional cover crop (CC) management strategies developed and adopted in temperate climates utilize seasonal transitions, plant senescence, and mechanical operations with or without additional chemical termination strategies to ensure effective CC termination. In tropical and subtropical climates, temperate strategies are not practical due to the cost of inputs, not possible (due to the absence of a killing frost to coincide with crop rotation transitions) and not beneficial to soil quality in the long term. Farmers with low-external input systems rely heavily on farm-derived resources such as CCs for soil and pest management. Tropical agroecosystems require unique CC management strategies that meet environmental and cultural conditions. The use of reduced tillage practices have been promoted to increase soil conservation and reduce on-farm expenses. The alternative termination method of rolling/crimping CCs to create surface mulch has gained attention because of the additional agroecosystem benefits it provides. Due to the persistent high temperatures in these climates, assessment of different mechanical CC termination methods is needed to avoid CC regrowth during production of income-producing crops. Cover crop cultural practices including species selection, seeding date and termination strategies, and the manner in which they influence weed diversity and density as well as vegetable crop yield and quality are the primary issues to define.

GOAL

Our overall goal is to develop cover crop technologies in minimum-till vegetable systems that minimize labor and external inputs and ensure competitive vegetable yields.

OBJECTIVES

A series of studies funded by SR-SARE were conducted on St. Croix USVI, Mayaguez PR, and Live Oak FL. Each location utilized RCBD with at least three replications and multiple years. Treatments were specific to study locations. Objectives shared among study locations included:

- Evaluate tropical CC species and identify their suitability for termination with a roller crimper.
- Assess mechanical roller-crimper CC termination on CC biomass and weed populations in the following crop rotation.
- Compare in situ CC surface mulch to plastic mulch, clay mulch, and conventional no mulch vegetable systems.
- Determine subsequent cash crop quality and yield.

METHODS

We evaluated tropical CCs for their ease of termination and ability to suppress weeds:

- Sunn hemp (Crotalaria juncea cv. INC-1), Tropic Sun, and an unnamed accession SH) Llabab (Lablab purpureus cv. Rongai) LL, Velvet bean (Mucuna pruriens L. SC cv. Adish) AD, and Dwarf VB, Jack bean (Canavalia ensiformis) JB
- Popcorn (Zea mays L. cv. B3311) PZ, and
- Sesame (Sesamum indicum L.) SE, and Sun flower (Helianthus annus L.) SF

CC, soil, and weed management treatments included:

Experiment 1: Comparison of standard mechanical CC termination methods (mow/incorporate) to roller crimper termination of erect CCs.

Experiment 2: Evaluation of tropical CCs pre and post termination with a roller crimper.

Experiment 3: Evaluation of selected tropical CCs, their response to roller-crimper termination, and the resulting surface mulch’s ability to provide ecosystem services in vegetable rotations (pepper, corn, plantain, and banana).

Experiment 4: Comparison of 4 vegetable crop production systems (plastic mulch, cut and carry hay mulch, and conventional no mulch) following SH as a CC.

Data collected included:

1. Cover crop and weed biomass, weed species, and weed density
2. Physical and chemical decomposition of SH and LL residue (litter bag analysis)
3. Post termination CC regrowth and weed biomass, weed species, and weed density
4. Crop quality and yield of jalapeño pepper (Capsicum annuum cv. Tormenta) in Florida and USVI or plantain (Mansonia major) and corn (Zea mays) in PR

LESSONS LEARNED

Successful systems are associated with:

1. Cover crop species selection that do not exhibit post-termination growth traits;
2. Significant cover crop surface mulch that is retained throughout the vegetable crop season; and
3. A reduction in weed establishment leading to reduced weeding frequency.

4. Integrated systems with legume living mulches reduced weeds between plantain rows compared with conventional systems, and resulted in increased plantain height and stalk diameter, and reduced the number of herbicide applications.

5. Fruit and vegetable yields in treatments receiving sunn hemp or sunflower surface sheet mulch are comparable to or greater than yields in conventional systems.

Limitations to the system include:

1. A limited number of cover crop species that respond to roller-crimper termination and
2. The overall additional management effort required relative to traditional vegetable systems.

Future work should include a critical examination of CC germplasm and suitability for meeting specific system objectives.

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INTRODUCTION

Conventional cover crop (CC) management strategies developed and adopted in temperate climates utilize seasonal transitions, plant senescence, and mechanical operations with or without additional chemical termination strategies to ensure effective CC termination. In tropical and sub-tropical climates, temperate strategies are not practical (due to the cost of inputs), not possible (due to the absence of a killing frost to coincide with crop rotation transitions) and not beneficial to soil quality in the long term. Farmers with low-external-input systems rely heavily on farm-generated resources such as CCs for soil and pest management. Tropical agroecosystems require unique CC management strategies that meet environmental and cultural conditions. The use of reduced tillage practices have been promoted to increase soil conservation and reduce on-farm expenses. The alternative termination method of rolling/crimping CCs to create surface mulch has gained attention because of additional agroecosystem benefits it provides. Due to the persistent high temperatures in these climates, assessment of different mechanical CC termination methods is needed to avoid CC regrowth during production of income-producing crops. Cover crop cultural practices including species selection, seeding date and termination strategies, and the manner in which they influence weed diversity and density as well as vegetable crop yield and quality are the primary issues to define.

OBJECTIVES

A series of studies funded by SR-SARE were conducted on St. Croix USVI, Mayaguez PR, and Live Oak FL. Each location utilized RCBD with four replications and multiple years. Treatments were specific to study locations. Objectives shared among study locations included:

• Identify suitable CC species
• Compare mechanical CC termination methods and assess their effects on CC regrowth.
• Evaluate broadleaf and grass weed suppression, and
• Determine crop quality and yield.

METHODS

We evaluated tropical legume CCs for their ease of termination and ability to suppress weeds:

1. Sunn hemp ([Crotalaria juncea cv. JAC-1 and an unnamed accession] SJ)
2. Lablab ([Llab purpureus cv. Rongai] LL), and

CC and soil management treatments included:

1. Mow CC and incorporate fully (rotary mower + 3x disc harrow)
2. Mow CC and incorporate minimally (rotary mower + 1x disc-harrow)
3. Mow only (rotary mower)
4. Roll down (roller-crimper)
5. Mow CC and incorporate fully followed by application of off-site cereal rye hay (Secale cereale cv. FL 401)

Data collected included:

1. Physical and chemical decomposition of SJ and LL residue (litter bag analysis)
2. Cover crop and weed biomass, weed species, and weed density
3. Crop quality and yield of either jalapeño pepper (Capsicum annuum cv. 'Tormenta') in Florida and USVI or plantain (Plantago major) in PR.

GOAL

Our overall goal is to develop cover crop technologies in minimum-tillage vegetable systems that minimize labor and external inputs and ensure competitive vegetable yields.

LESSONS LEARNED

Successful systems are associated with:
1. Cover crop species selection that do not exhibit post-termination regrowth traits;
2. Significant cover crop surface mulch that is retained throughout the vegetable crop season; and
3. A reduction in weed establishment leading to reduced weeding frequency.

Limitations to the system include:
1. A limited number of cover crop species that respond to roller-crimper termination and
2. The overall additional management effort required relative to traditional vegetable systems.

Future work should include a critical examination of CC germplasm and suitability for meeting specific system objectives.

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INTRODUCTION

Tropical smallholder farmers operating under low-external input (LEI) conditions rely on non-intensive on-farm or locally available inputs for agricultural production. However, some LEI agroecological systems. Cover crops (CC) provide a range of environmental and ecosystem benefits which range from soil protection and improvement to pest reduction.

Farmers with low-external input systems rely heavily on on-farm derived resources such as cover crops for soil and pest management. Tropical agroecosystems require unique CC management strategies that meet environmental and cultural conditions; the use of reduced tillage practices have been promoted to increase soil conservation and reduce on-farm expenses.

Conventional CC management strategies were developed for temperate climates where plant senescence is timed with seasonal transition for effective CC termination. Mechanical cutting followed by full incorporation of CC into the topsoil has been the accepted practice for CC termination but can result in soil decline from hilly production areas. A less labor-intensive alternative method of mowing/crimping CC to produce surface sheet mulch has gained attention as a more effective practice that reduces soil tillage and provides additional agroecosystem benefits. Due to the high water holding capacity of CC, the effectiveness of different mechanical CC termination methods is needed to avoid water or CC entering muddy ponds. A CC termination study was conducted on St. Croix in the U.S. Virgin Islands to test 4 different mechanical CC termination methods and their effects on CC regrowth, as well as biomass and grass weed suppression.

The primary objective of these studies is to develop tropical cover crop technologies for use as surface mulch in minimally tilled vegetable systems to provide alternative cover crop management strategies and ensure competitive yields.

Materials and Methods:
At the University of the Virgin Islands in St. Croix, sunn hemp and Lablab were planted on October 12, 2012, evaluated as CCS, and then terminated 120 days after planting. No additional external inputs were applied to the fields.

Termination treatments included: tested consisted of:

1) Full Incorporation with a disc harrow (3 passes).
2) Minimum incorporation with a disc-harrow (1 pass).
3) Mowing with a rotary brush mower (1 pass).
4) Roll down with a roller-crimper (1 pass).

Cover crop and weed biomass were determined prior to termination and 3-4 weeks post-termination. Weed species were separated by weed class and designated either a grass or broadleaf, or indistinguishable, separated in this trial. Cover crop was harvested and analyzed at 6, 9, and 12 weeks after termination and analyzed for plant chemical properties.

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Results and Discussion:
Sunn hemp yielded the highest amount of CC biomass at termination with 6,800 ± 683 kg/ha compared to LL at 3,126 ± 683 kg/ha. Lablab had greater plant tissue nitrogen (N) content than SH at 2.3% ± 0.1%, compared to 1.7% ± 0.2%, respectively. Due to the greater SH biomass, total estimated N contribution was greater for SH (117 ± 1.5 kg/ha ± 15) than for LL (70 kg/ha ± 15) (p<0.05). At 6 weeks after termination, SH had less regrowth, no regrowth, and in treatments compared to LL. Lablab had the greatest measured regrowth from treatment 2 (412229 Units ± 139) and similar regrowth in treatments 1, 3, and 4 (11 = 19.8, 91 ± 198, and 499 ± 198 respectively) (p<0.05). At 9 and 12 weeks after termination, SH regrowth was effectively controlled in all treatments with the only measurable regrowth occurring in plots treated with the roller-crimper (Table 2). In contrast, LL had greater levels of regrowth across most treatments for all three post-termination harvests and termination treatments 1, 3, and 4, and resulted in similar LL regrowth for each respective post-termination harvest date. Should the previous results be true for 9, 12 weeks after PH, regrowth from treatment 2 (1,229 Units ± 219) may be better suited for use as a CC in reduced tillage tropical agroecosystems. Sunn hemp controlled grass weeds in treatments 1, 2, and 4 through week 8, but similar and had similar biomass accumulation of grass weeds at week 9 of 0.6, and 196 ± 127 kg/ha, respectively. At 12 weeks after SH termination, broadleaf and grass weed levels exceeded 1000 kg/ha that all treatments except for treatment 1 which had the highest values of 619 ± 20 kg/ha and 54 ± 239 kg/ha, respectively (p<0.05). Therefore, full incorporation with 3 passes with the disc harrow resulted in the most effective termination and weed suppression method (at SH).