Selecting and Managing Cover Crops and Mixtures for Weed Suppression

Clemson Madren Conference Center
Clemson, SC – May 13, 2015

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What is a “Weed”?  

- An unwanted plant that becomes a pest.
- Whatever the grower did not plant but comes up anyway.
  - Such volunteer plants inevitably occur in any farming system that disturbs or exposes the soil.
  - Weeds are harmful to the extent that they compete with or otherwise hurt crops, pasture, and livestock.
  - Most weeds are also beneficial in that they “heal” soil “wounds” left by landslides, clearcuts, etc.
  - Invasive exotic weeds can directly harm indigenous soil microbial or plant communities.
The Weed Paradox

Weeds are the most costly category of pests in crop production.

Most cropland farmers consider weeds a top research priority.

Yet ...

*The onions are a complete loss, but the soil is protected.*
The Weed Paradox

If it weren’t for weeds, the world might have already run out of fertile topsoil. Why?

There are no weeds here, but the soil has suffered a catastrophe.
An Ecological Understanding of Weeds

Weeds are pioneer plants whose ecological role is to occupy, protect, and restore soil exposed by disturbance.

They are adapted to emerge and grow rapidly in these open niches.

In other words, weeds are doing an important job.

Common dayflower covered this road cut, thus curbing soil erosion and allowing perennial shrubs and young trees to become established within a few years after this photo was taken.
An Ecological Understanding of Weeds

Weeds – pioneer plants – perform several vital functions after fire, flood, tillage, timber harvest, or other disturbance leaves soil exposed:

• Protect the soil from erosion and degradation.
• Absorb and conserve nutrients.
• Replenish organic matter, feed soil life.
• Provide habitat for other organisms.
• Begin the process of ecological succession that restores the natural plant community.
Cropland Weeds:

• Are adapted to frequently disturbed, fertile soils.
• Germinate in response to light and other tillage cues.
• Grow and develop rapidly.
• Respond to, and take up abundant soluble nutrients.
• Reproduce prolifically by seed, or by rhizomes, tubers, or other vegetative means.

Common ragweed and jimsonweed in tomato
How Humans “Make” Weeds

• Decide what plants are “unwanted.”
• Hold succession back at early stages to produce desired crops (tillage).
• Create open niches (bare soil).
• Introduce exotic plants into the region.
What is a “Cover Crop?”

A crop planted, not for income, but to protect the soil from erosion and compaction, and to perform other agro-ecosystem services, including:

• Add organic matter, feed soil life.
• Mop up and conserve surplus nutrients.
• Fix N, make scarce nutrients more available.
• Provide habitat for beneficial organisms.
• Disrupt pest, weed, and disease life cycles.
• Suppress weeds.
What makes a “good” cover crop?

- Germinates, emerges, and grows rapidly.
- Covers the ground quickly.
- Absorbs and holds nutrients.
- Forms a lot of biomass.
- Fixes substantial N (legumes).
- Outgrows and smothers weeds.
- Easy to manage.
- Predictable, synchronous reproduction.
Ecological Weed Management

- Know the weeds, their life cycles, *their weak points*.
- Minimize open niches in the cropping system.
- Keep weeds guessing – *rotate crops, vary planting dates and types of field operations*.
- Grow healthy, competitive cash crops
- *Put the weeds out of a job - do it with cover crops!*
- Manage the weed seed bank.
- Knock weeds out with timely cultivation, flaming, mowing, etc.
- *Observe changes in weeds and respond accordingly.*
The Key to Managing Weeds Organically

Close that niche!

20th Century agriculture simplified the agroeco-system for convenience of industrial production.

Our job now is to design and build agroecosystems with high functional biodiversity.
Finding a Weed’s Weak Point: summer annual broadleaf seedlings

These small seedlings of common purslane, hairy galinsoga, and pigweed will grow rapidly in full sun.

If they emerge under a standing cover crop or a heavy mat of rolled winter cover crops, they might never “see the light of day.”
Finding a Weed’s Weak Point: shade-intolerant

Common purslane is so drought tolerant that severed shoots re-root readily and grow back. However, purslane cannot tolerate shade or grow tall, and it will lose vigor or even die out under a canopy of taller plants. Thus, most summer cover crops can choke it out.
Finding a Weed’s Weak Point: vulnerable to winter rye cover

Pigweeds and lambsquarters:
• Germinate in response to light
• Respond strongly to high soluble N
• Are susceptible to allelochemicals in cereal grains
• Seedlings are blocked by mulch

A winter rye cover crop mops up N, releases allelochemicals, and forms a thick, opaque mulch when roll-crimped – thus may be especially effective against these weeds.
Finding a Weed’s Weak Point: even the toughest weeds have at least one!

One of the worst weeds of hot climates, purple nutsedge propagates from underground tubers that can survive drought, flooding, and intense heat. Yet, it cannot tolerate much shade, and can be suppressed by a closed canopy of taller plants. For example - buckwheat, sunflower, a tall cowpea, or a combination of all three.
Open niches can invite weeds into vegetable crop rotations:

- *After vegetable harvest*
- *Over winter and before spring/summer planting*
- *Other breaks in rotation, e.g., hottest months*
- *From seeding until crop establishment*
- *Between wide-spaced rows*
Timely planting of winter rye + hairy vetch after vegetable harvest fully covered and protected the soil by winter (left). When the cover crop was sown too late, common chickweed did the job, perhaps not as well (right).
Relay planted cover crop closes post-harvest niche more rapidly

Clover cover crops were interseeded into brassicas (left) and tomato (right) when vegetables were at mid-growth. After vegetable harvest, clover rapidly covers the ground. This is in central Vermont – can we do it with other cover crops in a South Carolina summer?
No-till cover crop management reduces niche for weeds during crop establishment

A cover crop of rye + vetch was cut one week before transplanting broccoli. Very few weeds emerged through the cover crop mulch.
How Cover Crops Suppress Weeds

A growing cover crop can suppress weeds by:

• Competing for light, space, water, nutrients.
• Allelopathy – releasing plant growth inhibitors.
• Altering the light environment to make weed seeds dormant.
• Altering the soil microbial community to put some weeds at a disadvantage.

Winter rye + hairy vetch, a tried-and-true cover crop combination.
How Cover Crop Residues Suppress Weeds

After termination, cover crops can suppress weeds by:

- Physically hindering emergence of weed seedlings (if residues left on surface, e.g. roll-crimped)
- Allelopathy – products of decomposition are different from, and may be more potent than, root exudates from living cover crops.
- Supporting microbes that are pathogenic to weed seedlings.
- Tying up soluble soil N (high C residues) – a challenge and opportunity.
Every plant species gives off certain substances and fosters a particular soil microbial community, thereby affecting other plants. Learning how to utilize these complex chemical and biological interactions in designing crop rotations and selecting cover crops is a “cutting edge” in sustainable ag research.
Forage Radish (*Raphanus sativus*)

- Aggressive weed competitor
- Rapidly covers ground
- Plant in August, dense canopy closes in 3 weeks, winterkills in December (Appalachian region of VA)
- *Weed suppression persists into spring after winterkill*
- ‘Tillage radish’ is a cover crop variety of daikon – and it makes good eating too!

Fodder radish (shown) and daikon radish fight weeds and make excellent cover crops.
If radish kills weeds this dead, what will it do to spring vegetables?

Winterkilled radish leaves little residue but shows no weeds in March (left). Pearl millet + sunnhemp leave heavy residues yet allow weed growth (right).
Radish Cover Crop for Selective Weed Control and Enhanced Spinach?

No till spring spinach sown March 31, 2006 after winterkilled radish (left) and pearl millet + sunnhemp (right), photographed May 12. Results were similar when residues were tilled in.
More on Spring Vegetables After Radish

- Spotty spinach stands observed after all cover crop treatments except radish.
- Lettuce, pea, onion not affected by radish vs. other covers.
- Radish-spinach result seen in other trials (Beltsville, MD) and farms (Floyd Co., VA).
How did fall radish suppress spring weeds without hurting spring vegetables?

- Competition during fall weed emergence
- Light quality effect on weed seeds
- Soil biology – radish suppression of damping-off fungi that attack spinach
- Selective allelopathy? (unlikely)
Possible Cover Crop Pitfalls

- A thin cover crop stand can become weedy.
- Roll-crimping a thin cover crop for no till lets weeds through and interfere with cultivation.
- Cover crops can become weeds if they self-seed (buckwheat, vetch) or regrow after incomplete termination (rye, sorghum-sudan).
- N tie-up by a high-carbon cover crop can reduce crop growth.
- Plowing a N-rich cover crop may stimulate weeds.

Plowing down a vetch cover crop: will it kill weed seedlings by allelopathy, or just wake up the seeds and feed them with N?
The biggest pitfall: “it is not worth it”

Never judge or cost-assess a cover crop on its weed suppression alone. Cover crops also:

• Protect and build your soil, feed soil life, break hardpan, improve tilth & moisture retention.
• Help with nutrient management, protect water resources.
• Harbor beneficial insects.

Finally – this year’s failure can point the way to next year’s success.
Managing Cover Crops for Optimum Weed Suppression

• Choose the right cover crop for the time of year, and for your climate, soil, and cropping system.
• Use high quality seed.
• Prepare a weed-free seedbed.
• Optimize seeding dates, rates, depth, and planting method.
• Feed, lime, and water a cover crop if needed – but don’t feed the weeds!
• Grow cover crops to maturity – unless it gets weedy before then.
• Plant a multispecies cover crop.
Good Seed is Vital!

Seed quality made all the difference in this cover crop trial of forage soybean varieties for weed suppression.
Check that Seedbed!

• Lightly stir the soil surface and look for “white threads”
• Waiting just five days from seedbed preparation to planting can mean a weedy cover crop.
• Cultivate shallowly in sunny weather just before seeding to knock out germinating weeds.
Charlie Maloney of Dayspring Farm skillfully broadcasts rye + vetch at 50 + 25 lb/ac with a spin seeder ($40), then rototills one inch deep, taking out any small weeds while planting the cover.
Cover Crop Planting Technique

Uniform, thick stands of rye + vetch shown 4 (left) and 11 (right) days after broadcasting and shallow incorporation at Dayspring Farm, on a sandy loam in the Tidewater region of Virginia.
Cover Crop Gallery

For more information, see the SARE manual, Managing Cover Crops Profitably, or visit eOrganic or eXtension sections on cover crops
Winter Rye (*Secale cereale*)

- Strong weed suppression by competition and allelopathy.
- Scavenges and holds N.
- Roll-crimped residue blocks weeds for 4-8 weeks.
- Plant late summer to mid fall, terminate April-June.
- Plant 1” deep, 100 lb/ac alone, 50-60 lb/ac with legume.
- ‘Abruzzi’ rye for South.
- Roll-crimp in early seed development (soft dough).
Spring Oats (*Avena sativa*)

- Good weed competitor, some allelopathy.
- Scavenges soil N, moderate C:N, less N-tieup than rye.
- Plant early spring, terminate Jun-July, or plant Aug-Sep to winterkill (15 °F) or terminate in spring.
- Plant 1” deep, 100 lb/ac alone, 50 lb/ac with legume.
- Not drought tolerant.
- Companion with annual legumes

*Spring oats, sown in late August, forms thick cover by October.*
Other Winter Cereal Grains

Winter Barley (*Hordeum vulgare*)
- Hardy to about 10°F
- Tolerant to drought and moderate salinity
- Allelopathic

Winter Wheat (*Triticum aestivum*)
- Hardy to <0°F, hard to roll-kill, otherwise similar to winter rye

Triticale
- Tall, strong-stemmed, easy to roll-kill, similar to winter rye
Hairy Vetch *(Vicia villosa)*

- Weak to moderate weed suppression alone, but enhances suppression by rye.
- Strong N fixer, beneficial insect habitat.
- Plant 25-40 lb/ac, ½ - 1 in deep with cereal grain in fall.
- Can become weed – use scarified seed, terminate at bloom.
- Moderately easy to roll-crimp, may need 2 passes.
Crimson Clover (*Trifolium incarnatum*)

- Moderate weed suppression alone, better with cereal grain.
- Winter annual legume, plant late Aug-Oct., terminate April
- Companion with rye or other cereal grain
- Self seeds readily, can become weed if mature seeds formed.
Crimson Clover - more information

• Sow 15 - 30 lb/ac, ¼ - ½ inch deep, or broadcast & cultipack
• Hardy to 0 – 10°F
• Easier to manage and roll-kill than vetch
• Matures earlier than hairy vetch & most rye; matures with barley, Abruzzi rye

Crimson clover growing with winter barley (Hordeum vulgare)
Austrian Winter Pea (*Pisum sativum*)

- Fair weed suppression alone, excellent with cereal grain.
- Plant early spring, late summer, or fall.
- Sow 70-100 lb/ac alone or 50 lb/ac with cereal grain, 1” deep.
- Hardy to -5°F if sown late, winter-kills at 15-20°F if sown early.
- Easier to roll-crimp than hairy vetch, not weedy.
- Not drought tolerant.
- Excellent edible pea tips!
Forage Radish (*Raphanus sativus*)

- Strong weed suppression, but not allelopathic against crops.
- Can scavenge 150 lb N/ac.
- Sow 10 – 15 lb/ac, ½ inch deep.
- More drought tolerant than oats, establishes well in late summer.
- Winterkills at about 20°F, may overwinter in Zone 8.
- Residues degrade quickly, leave bare soil after winterkill.
- Spring plantings may bolt before achieving desired size.

Daikon radish, a.k.a. tillage radish, is both vegetable and cover crop.
Red Clover (Trifolium pratense)

- Good weed suppression once established.
- Good N fixer, mobilizes soil P.
- Subsoiler (deep taproot).
- Clover-grass sod restores soil health, promotes tilth, reduces annual weed seed bank.
- Beneficial insect habitat.
- Plant spring or late summer, grow 8 months – 2 years for break in annual crop rotation.

Red clover is a short lived perennial (2-3 years) that is easy to establish in open feld or as overseed in a standing crop.
Red Clover (*Trifolium pratense*)

- Easy to establish in cool to moderate temps, not in summer heat.
- Sow 10 – 15 lb/ac, drill ¼ inch deep or broadcast alone or with perennial grass.
- Sow with “nurse” crop of oats at 40 – 50 lb/ac
- Very shade tolerant, can overseed into standing vegetable or grain crop.

*Red clover was sown in alleys between tomato rows in early summer, and became well established by October in Vermont.*
Sweetclover (*Melilotus officinalis*)

- Suppresses weeds once established.
- Subsoiler – deep taproot.
- High biomass, fixes N, mobilizes P, beneficial habitat.
- Plant 15 lb/ac, or Aug alone or with oats, red clover or grasses; grow until following spring (biennial).
- Can roll-crimp at full bloom.

Yellow sweetclover, about one year after planting, is almost ready to bloom.
Buckwheat (*Fagopyrum esculentum*)

- Strong weed suppression by rapid canopy closure, competition, and allelopathy.
- Excellent for short fallow (30-50 days) during frost-free period.
- Excellent nectar plant for natural enemies of crop pests.
- Mobilizes soil phosphorus.

The buckwheat has nearly covered the ground by 14 DAP.
Buckwheat (*Fagopyrum esculentum*)

**Tips:**

- Sow 75 – 100 lb/acre, ~ ¾ inch deep.
- Frost tender annual
- Dislikes drought and intense heat
- Decomposes quickly, low residue
- Self-seeds readily → second generation, or becomes weed

*Buckwheat in full bloom supports beneficial insects*
Sorghum-sudangrass  
(*Sorghum bicolor X sudanense*)

- Good weed suppression by competition and allelopathy
- Very tall, high biomass (4 to 6 t/ac)
- Plant when soil is thoroughly warm (70°F), 25-50 lb/ac, ½ - 1” deep
- Cut back at 4 ft, before heading to stimulate deeper rooting.
- Requires plenty of nutrients, esp N.
- Drought tolerant.
- Quite hard to kill by roll-crimping or mowing, but will frost kill at 30°F
- Ties up N, especially if incorporated.

*Sorghum-sudan* (with lablab bean) has reached 9 ft.
Pearl Millet (*Pennisetum glaucum*)

- Good weed suppression
- Tall (4-10 ft), high biomass (5 t/ac).
- Grows back and sends roots deeper if cut before heading, can terminate after heading by roller-crimper.
- Tolerant of lower fertility.
- Less apt to tie up N severely than sorghum-sudan.
- Sow 10-20 lb/ac, ½” deep.
- Highly drought and heat tolerant
- Killed by 30°F frost
Foxtail Millet (*Setaria italica*)

- Good weed suppression
- Summer annual, 60-75 day fallow, plant before solstice at 10-20 lb/ac
- Easy to roll-kill after heading
- June plantings – 3 t/ac; later plantings – little biomass or weed suppression.
- Not likely to become weed even if it sets some seed.

*Foxtail millet or German millet, heading at about 60 days after planting*
Cowpea (*Vigna unguiculato*)

- Rapidly covers ground, strong weed competitor.
- Food or forage crop, beneficial habitat.
- Plant when soil warm, May-Aug.
- Sow 60 – 100 lb/ac, ¾ – 1” deep.
- Fairly shade tolerant – can plant with tall grass or relay-intercrop.
- Very drought-tolerant.
- Frost-tender, heat-loving.

*Cowpea forms a dense canopy that can smother weeds.*
Forage Soybean (*Glycine max*)

- Tall forage varieties give good weed suppression.
- Choose late maturity group (VI or later), e.g. Tyrone
- Plant after spring frost through July, at 80 – 120 lb/ac, 1 – 1.5 inches deep.
- Frost tender, moderate heat and drought tolerance.
- Can reach 4 t/ac biomass, 200 lb/ac N.

‘Tyrone’ forage soybean forms high biomass and N
Sunnhemp (Crotolaria juncea)

- Suppresses weeds, nematodes
- Plant when soil warm, May-Aug, 20-50 lb/ac, ~1” deep.
- Tolerates drought and heat
- Very tolerant of low soil fertility.
- Tall (6 ft); excellent companion for sorghum-sudan, millets.
- Tough stems, but can be killed by mowing or roll-crimping.

Sunnhemp growing with pearl millet
Lablab bean and velvet bean

• Large, heavy vines, heavy canopy, good weed suppression.

• Tropical legumes, require warm soil.

• Very large seed, sown at low rates far apart, may need cultivation like row crop until established.
Other Cover Crops

- Other crucifers: turnip, various mustards, canola – each has different set of glucosinolates and different weed, nematode, and pathogen-fighting properties.
- Sunflower – black oilseed (bird seed) is cheap and easy to get – provides biodiversity in summer covers, allelopathic.
- Phacelia – cool season.
- Teff – warm season cereal grain.
Diversity is the Key

• Multi-species cover crops maximize benefits by:
  – More completely filling niches to exclude weeds.
  – Providing complementary allelopathic effects.
  – Ensuring success over varying conditions.
  – Supporting a more diverse soil food web.

• Build functional diversity in cover crops and throughout crop rotation.

• There are no formulas – site specific process!
  – Must ensure mixes are compatible and balanced.
  – For roll-crimping, maturity must be synchronized.
Cover crop Bicultures and Polycultures

Advantages of grass + legume:

• Wider adaptability than monoculture.
• *Complementary architecture* fills niche and suppresses weeds more effectively.
• Enhanced N fixation.
• Often higher biomass.
• Balanced C:N “feeds” soil better, no N leaching or tie-up
• Supports soil microbial diversity

Rye + vetch suppressed winter weeds better than either alone in field trials. Rye supported vetch vines; vetch provided N to rye.
Rye + vetch residues (left) enhanced both weed control and crop yield in no-till broccoli, compared to rye alone, which reduced availability of N to the vegetable crop (right). Rye + vetch also suppressed a wider range of weeds than rye alone, which allowed horseweed (C. canadensis), or vetch alone, which encouraged pigweeds and other “N responders.”
A four species mix for spring

- Planted in March, grown until mid June.
- Followed by summer vegetables.
- Note how the different structures of the grasses, legume, and crucifer really occupy the niche in a solid stand.
- Some weeds emerged with the cover, and got smothered later on!

*Spring cover crop of oats, barley, peas, and mustard*
A five species mix in summer

A mix of buckwheat, sorghum-sudan, pearl millet, cowpea, and sunflower looked like buckwheat at first, but the grasses and cowpea filled in later.
Summer-fall mix

Relay crop of tender (millet, sorg-Sudan, cowpea) and semi-hardy (radish, mustard, oats, Aus. Pea). High biomass by October 8. The tillage radish tasted great too!