WSU Puyallup Reduced Tillage Organic Agriculture & Irrigation Management Field Day
1 August 2016

Contents

This research is supported through grants from the Western Sustainable Agriculture Research and Education program, WSU's Center for Sustaining Agriculture and Natural Resources, Biologically Intensive and Organic Agriculture Program, and G.A. Harris Fellowship (Decagon Devices).

Project Overview

Project Directors: Doug Collins, Chris Benedict, Andy Bary, Liz Myhre.

Current Graduate Students: David Sullivan, Ryan Tarbell

Research Technician: Kyle Brown; Undergraduate Interns: Tuong Vu (WSU), Emma Davis (PLU)

Farmer Cooperators: Colin Barricklow, Kirsop Farm; Steve Hallstrom, Let Us Farm; Adam McCurdy, Oxbow Farm; Tom Thornton, Cloud Mountain Farm; Martin Frederickson, Twin Vista Ranch

Project Goal: Through this project we are striving to find systems that reduce frequency and intensity of soil disturbance during organic vegetable production. Strip till and no-till are being compared to full till in the production of winter squash, broccoli, and beans. Rotational reduced tillage and continuous reduced tillage are also being compared.

Cover crops are grown and terminated to leave a thick weed-suppressing mulch on the soil surface. Cover crops in our trials are terminated without herbicides or tillage by flail mowing or using a roller/crimper.

Many soil quality parameters have been evaluated, including: earthworms, microbial biomass, greenhouse gases, nematodes, bulk density, soil compaction, infiltration, soil temperature, soil moisture, light penetration, and the weed seed bank. Weed pressure, time spent weeding, crop yield, fuel usage and cover crop biomass have also been evaluated.

Specific questions that guide our current work include:

1. Which implements and strategies are most effective to manage residue in strip-tilled ground?
2. How does reduced tillage affect nutrient cycling and fertility management?
3. Does reduced tillage improve water use efficiency?
4. Which cover crops, mixes, and termination strategies perform best?
5. What specific challenges and opportunities do continuous reduced-tillage present?
6. What strategies improve transition to reduced tillage?

Key findings:

1. Tillage reduces large-bodied earthworm populations compared to reduced tillage.
2. Tillage increases soil carbon dioxide emissions compared to reduced tillage.
3. Annual weeds are suppressed by terminated cover crop mulches
4. Tillage increases soil temperature and increases evaporation.
5. Bulk density and compaction are decreased by tillage.

6. Equipment for reduced tillage organic agriculture is highly specialized. Fabricating or modifying existing tools designed for use in conventional reduced tillage operations may be necessary.
7. Adoption of reduced tillage organic agriculture will likely depend on efficient weed control. Initial weed pressure is important; manage for the transition.
    a. Two possible paths to success:
        i. “Ideal” in most people’s minds and possible in reality is high residue (e.g. greater than 3.5 tons/acre dry matter, most likely a cereal) that suppresses weeds. Combine this with hand-weeding and possibly high-residue cultivation.
        ii. Lower residue cover crop (e.g. less than 2 tons/acre dry matter, possibly a legume or mix). Perhaps some short-term weed control, combine with high-residue cultivation

Long-term Reduced Tillage Experiment: In fall 2011 we initiated a long-term reduced tillage cropping systems experiment with three cash crops in rotation and adaptive management to incorporate new cover crops and equipment improvements. This experiment is referred to as “Crimp 4” (see Plot Map). The 6 cropping systems in the trial vary in cover crop termination and ground preparation method. Treatments include:

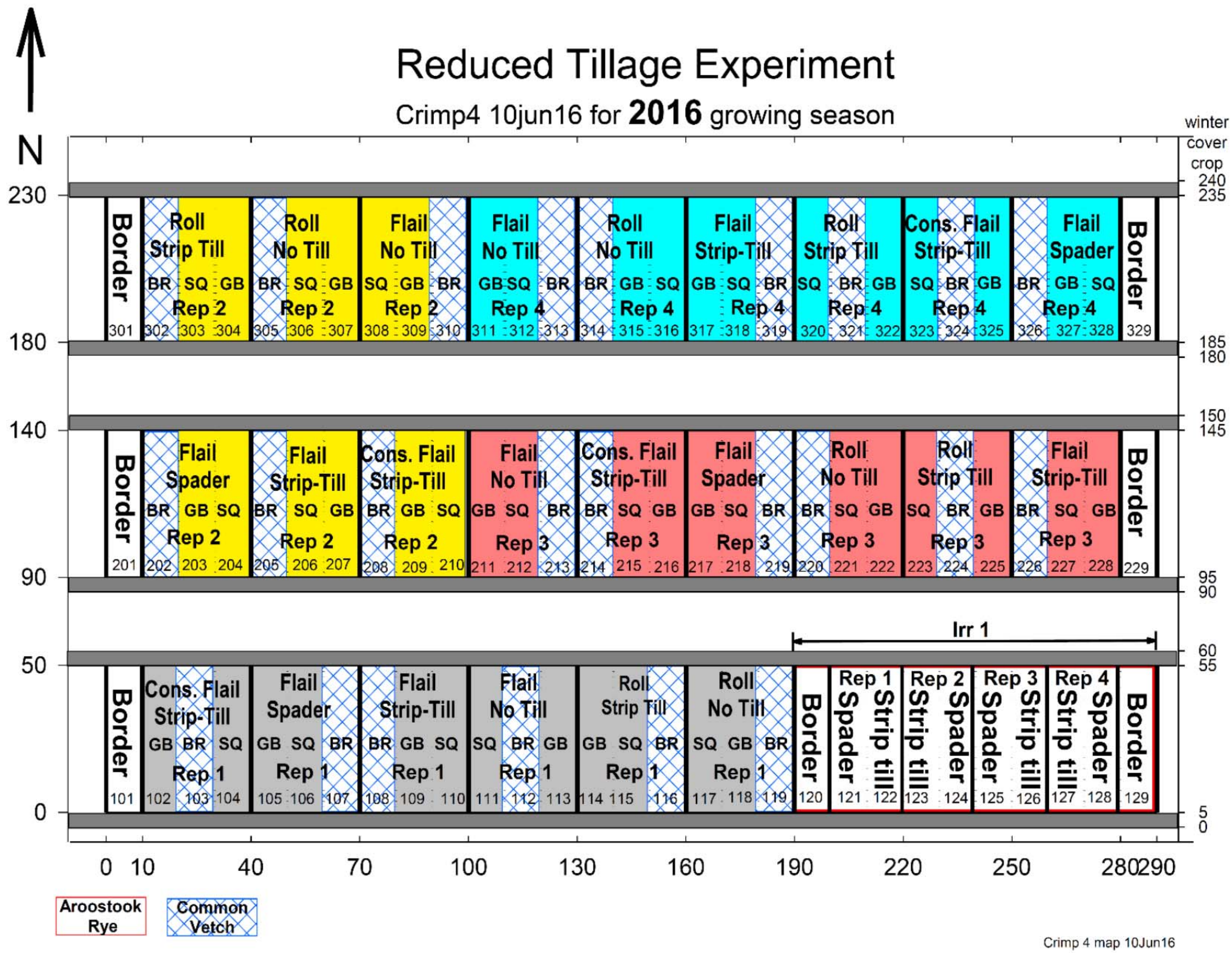
1. Flailing+NoTill
2. Flailing+StripTill
3. Roll/Crimp+NoTill
4. Roll/Crimp+StripTill
5. Full Till
6. Continuous MinTill+Flailing+StripTill

Treatments 1–4 are rotational reduced tillage treatments; tillage is used in the fall to prepare a seed bed for establishing cover crops. In the spring, cover crops are terminated then ground prepared for transplanting with a reduced-tillage strategy. Treatment 5 utilizes a spader in spring and fall. Treatment 6 is a continuous minimum-till treatment.

We are committed to providing support to organic producers interested in implementing reduced tillage techniques on their farms.

Reduced Tillage Experiment

Crimp4 10jun16 for **2016** growing season



Reduced Tillage Equipment

Landpride 3P 500 Min-Till Drill allows cover crop seeding with minimal soil disturbance. Also used to seed green beans in reduced tillage trial.

WSU Puyallup Powered Strip Tiller

Combination of Maschio K Series multivator, Dawn Coulter Combo w/ screw adjust and ripple coulter, and 40 inch Roll-A-Cone ripper shank. Toolbar manufactured and assembled by Whatcom Manufacturing, Lynden, WA.

Henke Buffalo 6600 Culitivator, 2 row on 75" 5X7 Bar. Open top shields.

Mechanical Transplanter 5000WD with No-Till Attachment

Cover Crop Decomposition Dynamics in Organic, Reduced Tillage Systems

Ryan Tarbell, Research Technician, Organic Farmer, and WSU M.S. Ag Student; Hayfork, CA

Understanding the quantity and timing of nitrogen availability from terminated cover crops is important to help conserve fertilizer applications and maintain optimum yields. Plant available nitrogen (PAN) from cover crop residue incorporated into the soil can be estimated (Sullivan and Andrews, 2012). Organic, reduced tillage systems are more problematic to estimate PAN because the cover crop residue is left on the soil surface acting as weed suppressive mulch and decomposing at a much slower rate. This cover crop decomposition study will help provide insights into the decomposition rate and PAN availability between conventional tillage, strip tillage, and no-till treatments.

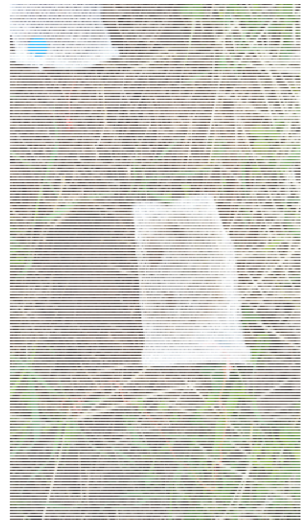
Cover Crop Decomposition and PAN

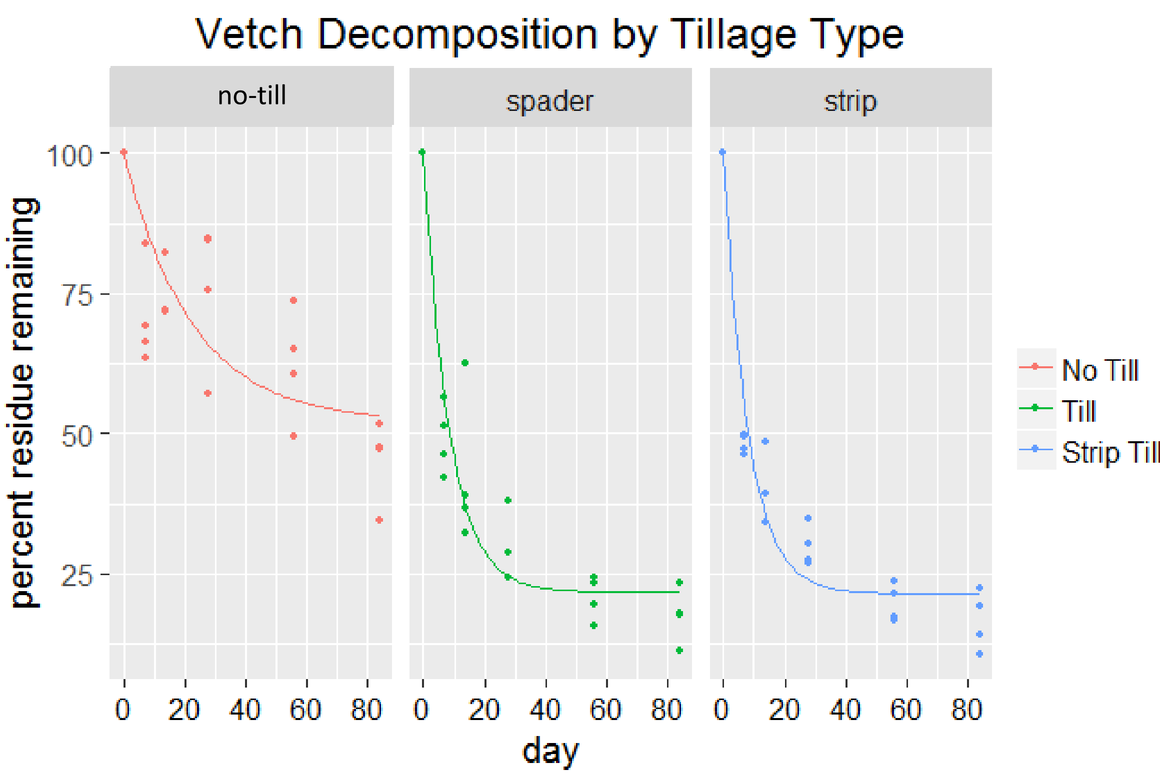
- The rate of cover crop decomposition is influenced by several factors including moisture, temperature, oxygen availability, microbial populations, and chemical composition of cover crop.
- Residue placement (i.e. surface, or incorporated) affects the factors controlling the rate of residue decomposition
- Plant available nitrogen (PAN) release or immobilization from cover crops can be predicted by the N percentage of the cover crop.
- Cover crops with less than 1.5 percent N in DM will immobilize N, while cover crops over 1.5 percent N will release PAN (Sullivan and Andrews, 2012)
- The rate of PAN release under conventional tillage generally occurs within 4-6 weeks.
- PAN release from a cover crop with 3 percent N DM will be approximately 33 lb N/acre for each ton of cover crop DM (Sullivan and Andrews, 2012)

Experiment Overview

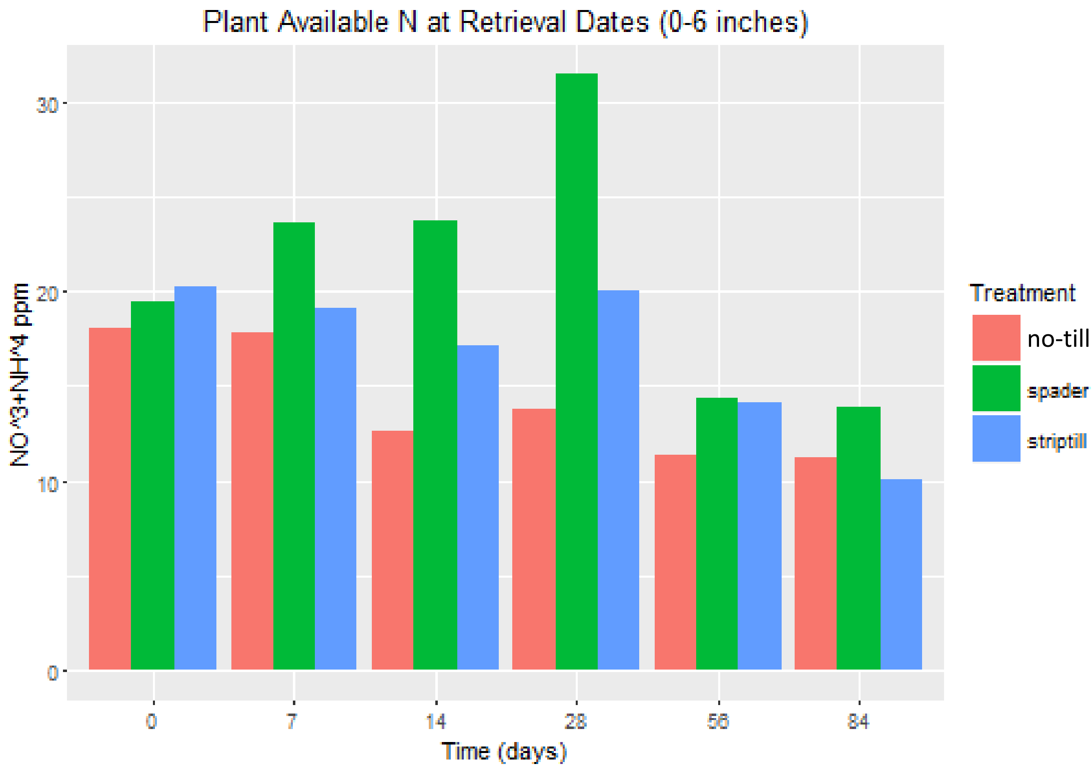
- Common vetch terminated by flail mowing at 100 % bloom.

- Nylon mesh residue bags were packed with vetch and placed in full tillage, strip-tillage, and no-till treatments.
- The residue bags were placed on the surface in the no-till treatment and buried 10 cm deep in the strip-till and spader treatments.
- All bags were placed in unfertilized broccoli beds, but the adjacent broccoli bed was fertilized with 71 lb N/acre feather meal.
- Residue Bags were retrieved from the treatments on five sampling dates
- Bags were analyzed for percent residue remaining and the results were corrected for soil contamination.
- 0-6" soil samples were taken in all plots on all sampling dates and analyzed for nitrate and ammonium

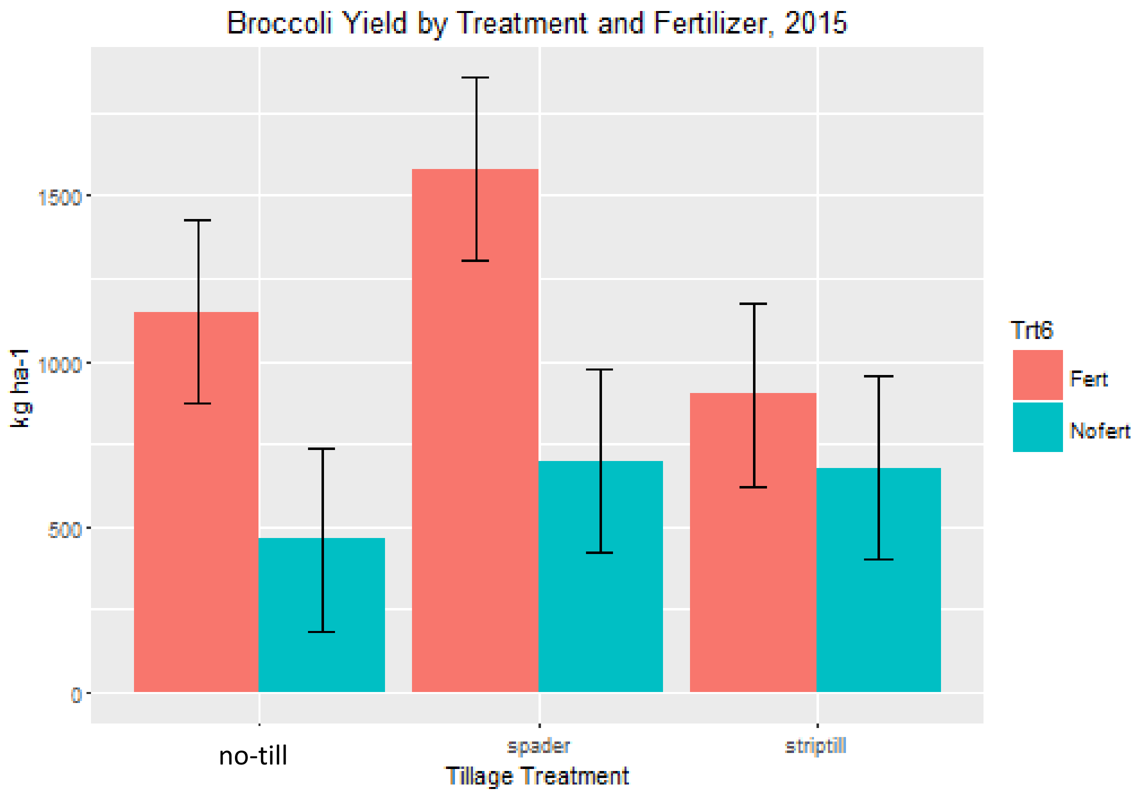




Tillage influenced the rate at which the vetch residue decomposed. The labile component of the vetch residue rapidly decomposed within 4 weeks in spader and strip-till treatments. Residue continued to decompose in the no-till treatment after 12 weeks.



This graph depicts ammonium and nitrate availability at five sampling dates throughout the growing season following placement of residue bags in the field (day 0). Residue bags were placed into the field on the same day as cover crop incorporation in spader and strip till treatments and 7 days after vetch termination. All three treatments had similar PAN levels at day zero. In the spader treatment, vetch residue was rapidly decomposed until day 28 and pooled in the soil. Broccoli uptake of N increased after day 28 and PAN levels dropped. In the no-till treatment PAN levels drop steadily throughout the study period indicating the vetch decomposition rate along with organic matter mineralization is lower than broccoli N uptake. Although the decomposition rate of the strip-tillage is similar to the spader treatment, PAN availability is lower in the strip-tillage treatment compared to the spader treatment. This difference could be explained because of lower soil temperatures in the strip tillage treatments, or the 3 ft. of surface residue that surrounds the strip tillage zones in each broccoli bed providing slower access to PAN.



Tillage treatments and corresponding broccoli yields were not significantly different. Fertilization did have a significant effect upon yield ($p<0.001$).

Key Findings

- Tillage treatments did not significantly alter yields
- PAN availability is lowest in the no-till treatment, but by day 56 PAN levels are comparable across tillage treatments
- Fertilization is necessary in reduced tillage systems for optimum yields
- Nearly half of the residue in the no-till treatment remained at day 85, and would likely make PAN contributions the next growing season

Resources:

Sullivan, D.M. and N.D. Andrews. 2012. Estimating plant available nitrogen release from cover crops. PNW636

Soil Moisture and Irrigation Scheduling Basics

David M. Sullivan, Graduate Research Assistant, WSU M.S. Soil Science Student,
Puyallup Research and Extension Center

Common irrigation methods:

- **"Kick the dirt":** What results when there is no formal plan. We want to get away from this.
    - Leads to both under and over irrigation.
    - Once the soil starts looking dry or plants exhibit stress its too late.
    - What's wrong with over irrigating?
        - Wasted expense on energy and resources
        - Can lead to crop stress
        - Nutrient leaching (flushing beyond the reach of roots)

- **Weekly fixed schedule –** Irrigating based off average crop demand.
    - Leads to over irrigation early in the season and often under irrigation during crop maturity

- **"Checkbook Method":** Manually balancing soil moisture through ET (Evapotranspiration), and inputs of irrigation/rain. Similar to balancing a checkbook.
    - Requires dedication to close record keeping.
    - Excel templates are available through many extension programs.
    - Can be time consuming.

- **Monitoring soil moisture**- Using sensors or manual estimation to measure real time soil moisture and irrigating when soils reach a set trigger.
    - Accurate equipment can be costly yet cheaper options are available.
    - Need to account for differing soil types and conditions between fields.
    - Manual soil moisture estimation guides ("soil moisture by feel") are available through extension, but estimation by hand is time consuming and limited to higher soil depths.

- **Irrigation scheduling models**: Uses weather stations to estimate crop water use and required irrigation.
    - Many free models are available (like WSU AgWeathernet irrigation scheduler mobile).
    - Garbage in = garbage out:
        - Close attention must be made to update models to match crop development, soil types.
    - In field "reality check" moisture measurements are recommended to validate model
    - ***Pairing models with daily soil readings results in accurate scheduling and is considered best practice.***

• Determining available water capacity

- **Volumetric water content (VWC)** is the percentage of water present per unit volume of soil. VWC measurements help us determine "how much" to irrigate.
- **Soil water potential** tells us "when" to irrigate: Not all soil moisture is available for plant uptake as it adheres to soil particles tightly and cannot be accessed by roots. This "availability" is measurable and often discussed as "matric potential" or "water tension".
- Soil moisture availability can be measured directly (water potential sensors) or derived from volumetric water content sensors if the soil texture is known. A soil's total plant available water is the volume of water between field capacity and permanent wilting point. Note that finer textured soils hold more total available water than course soils.
- **Field capacity (FC)** is the maximum amount of water that a soil can hold indefinitely against gravity
- **Permanent wilting point (PWP)** is the amount of water remaining in the soil after plants can no longer pull water from the soil (wilt and die)

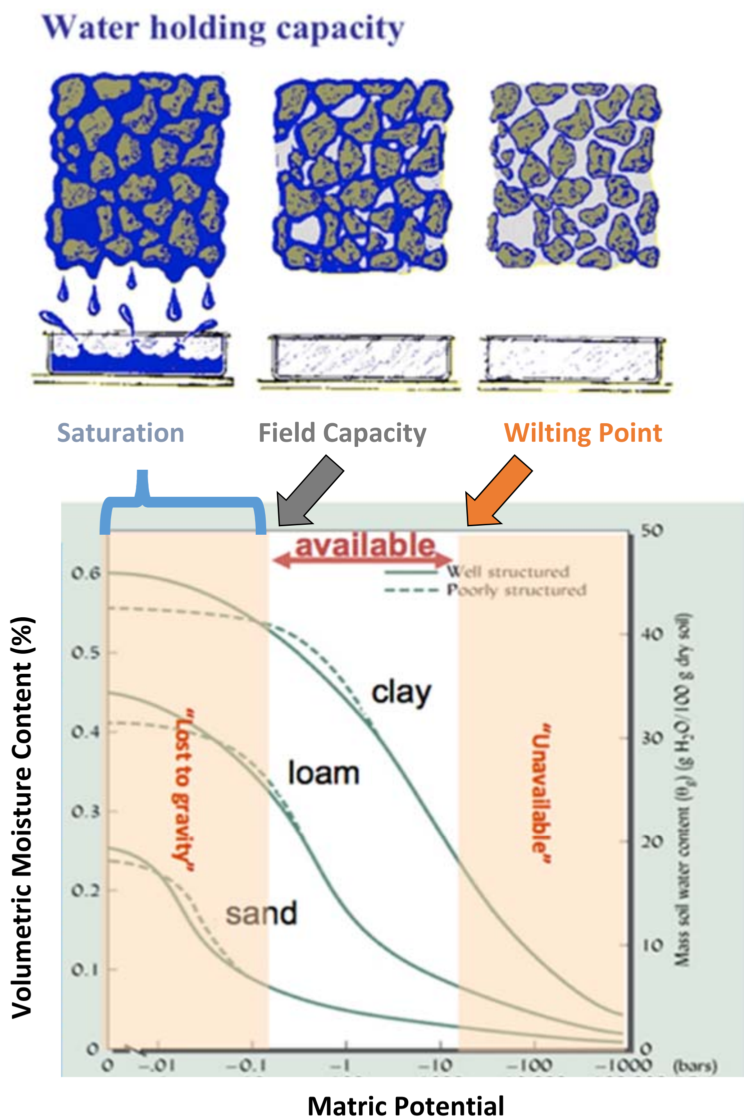


Figure 1a. Moisture release curves for sand, loam, and clay soils.
Figure 1b. (top) Saturation, Field Capacity, and Wilting Point levels

Table 1. Ranges of available water by soil texture (PNW Irrigators Pocket Guide).

Soil Texture	Available Water Capacity (AWC) in/ft
Coarse Sand	0.2–0.8
Fine Sand	0.7–1.0
Loamy Sand	0.8–1.3
Sandy Loam	1.1–1.6
Fine Sandy Loam	1.2–2.0
Silt Loam	1.8–2.5
Silty Clay Loam	1.6–1.9
Silty Clay	1.5–2.0
Clay	1.3–1.8
Peat Mucks	1.9–2.9

Your soil water capacity is like a "bucket"

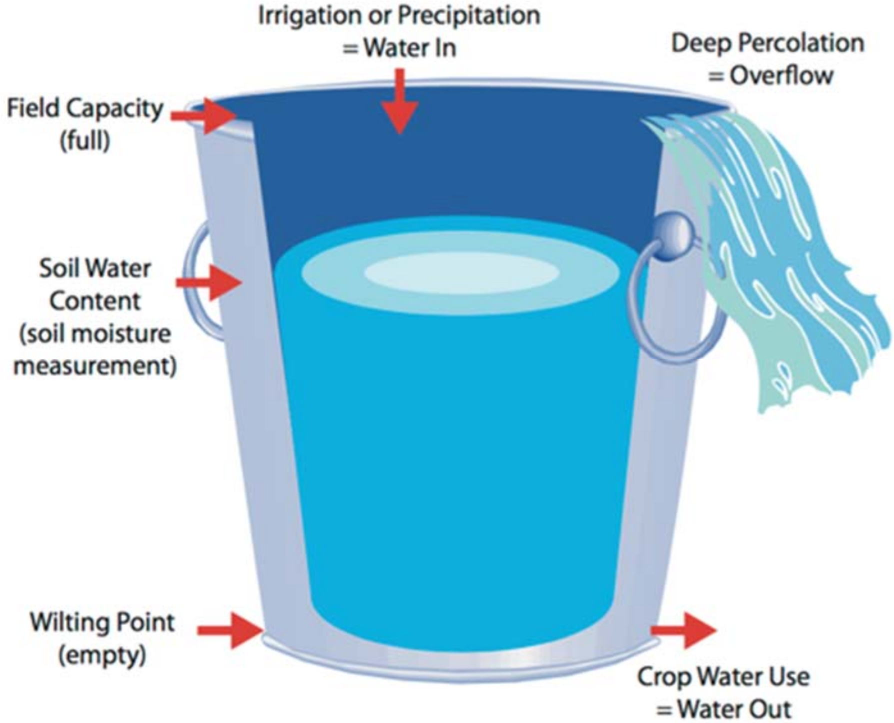


Figure 2. Soil can be thought of as a bucket for storing water and nutrients. Water is removed through evaporation and plant transpiration (ET) as well drainage (deep percolation). The bucket is then filled through irrigation or rain. Field capacity and wilting point is represented by the bucket being either "full" or "empty"

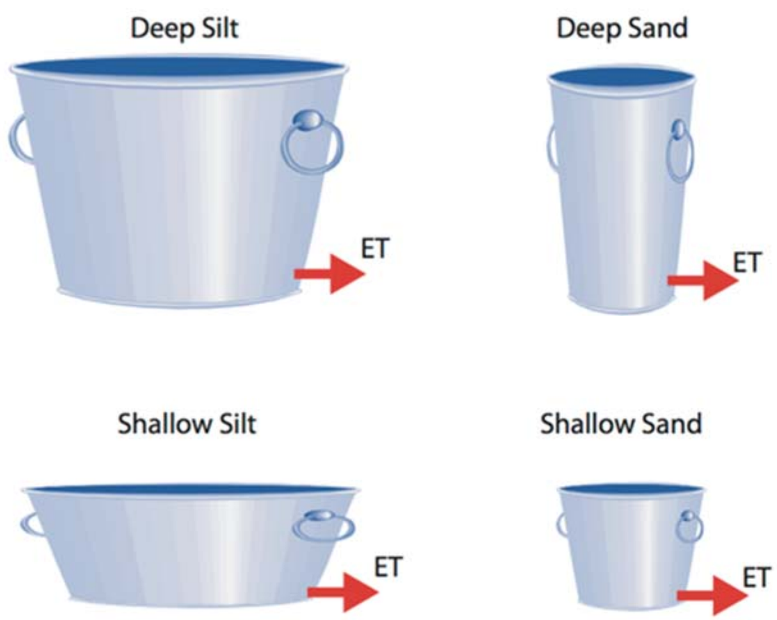


Figure 3. The water-holding capacity of the soil as well as the plant root depth will determine the size of your "bucket" (available water). Crop water needs (ET) will be roughly the same regardless of soil type or depth.

Triggering M.A.D.

We generally want to irrigate before yield limiting plant stress occurs. This moisture level is the "Management allowable deficit" (MAD) or the irrigation trigger. The MAD is expressed as a percent deficit of plant available water from the soil's field capacity. Each crop ha s a different MAD.

Figure 4. Example MAD trigger in relation to various levels of soil water content

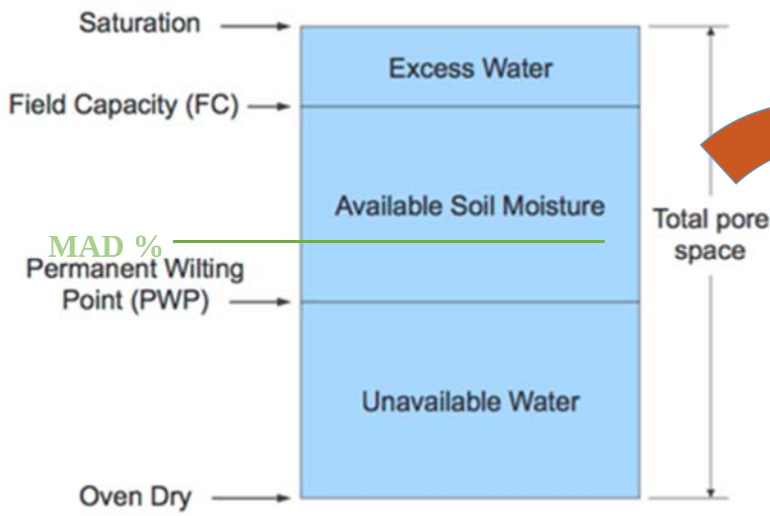


Table 2. Suggested MAD points and typical rooting depths for various crops. Actual values may differ due to restrictive soil layers or other site differences.

Crop	MAD (%)	Rooting Depth (ft)
Alfalfa	55	4
Asparagus	50	4
Beans	40	2.5
Blueberries	50	3
Carrots	50	2
Corn	50	3
Grapes	50	3.5
Green Beans	50	2
Hops	50	4
Mint	35	2
Onions	40	1.5
Pasture/Clover	50	2.5
Peas	50	1.5
Potatoes	30	1.5
Raspberries	50	3
Safflower	50	4
Spring Grains	50	3
Strawberries	50	1
Sugar Beets	50	3
Sweet Corn	40	3
Tree Fruit	50	3.5

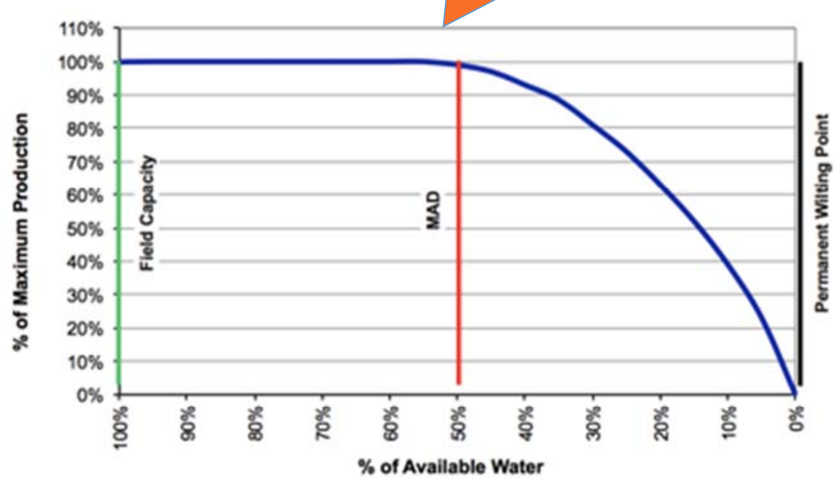


Figure 5. A generalized curve showing how plant production (growth) is affected by soil water stress.

WSU AgWeathernet Irrigation Scheduler

AgWeathernet is a collection of WSU weather stations which track and store environmental data throughout the state. Local weather station data is then used via the irrigation scheduler to track rainfall inputs as well as model ET for a wide selection of crops.

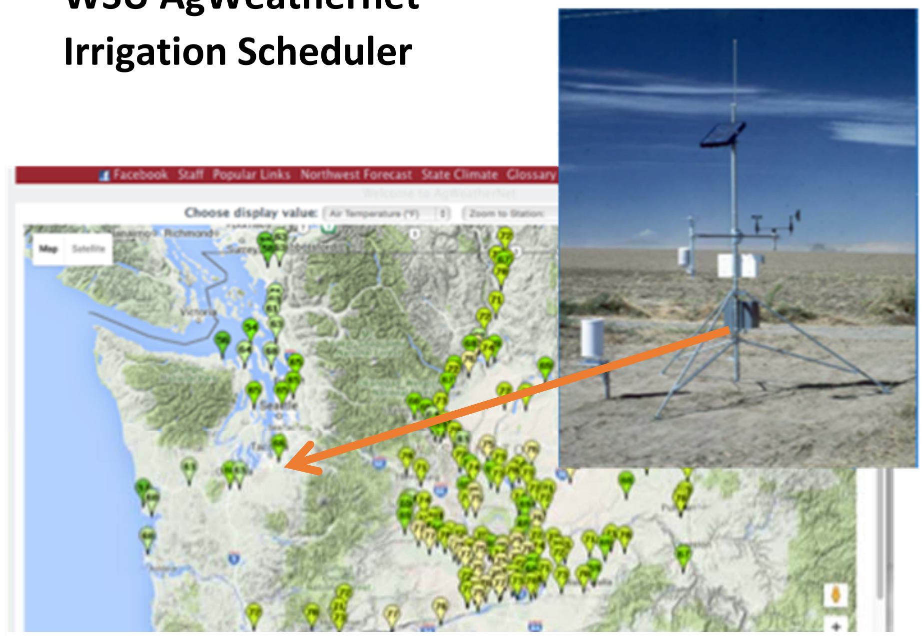
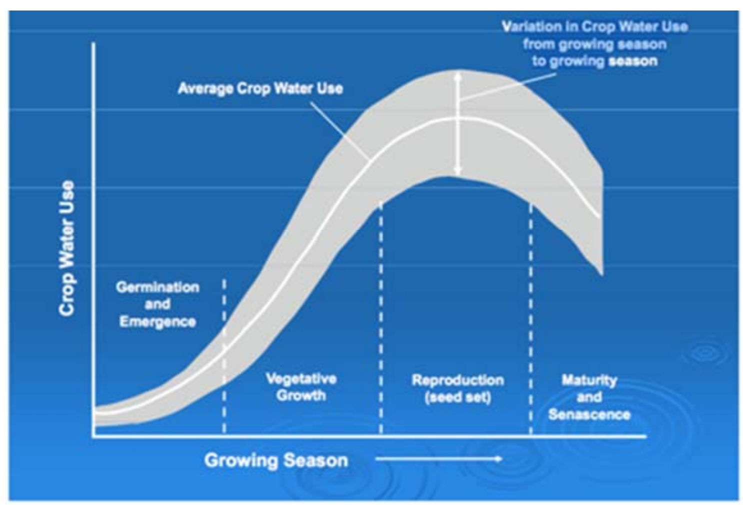


Figure 6. AgWeathernet station network throughout Washington state. Example weatherstation (top right)

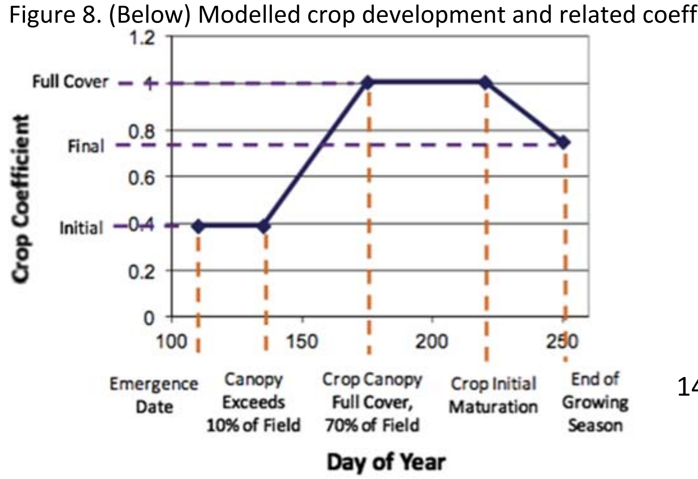
Crop water use increases throughout the growing season as plant canopy and rooting depth increases, eventually reducing after reproduction/seed set.

Figure 7. Crop development and resulting water use during a growing season (below).



The Agweathernet irrigation model accounts for these changes in ET through varying the "crop coefficient" within the model. Users will need to monitor crop growth and input various maturity stage dates to account for this.

Figure 8. (Below) Modelled crop development and related coeffiecients



AWN Scheduler mobile screenshots
(browser and phone app)

Figure 9. Front Screen/Dashboard showing current day moisture status. Moisture defecit from field capacity given in either inches or hours (zero for this example).

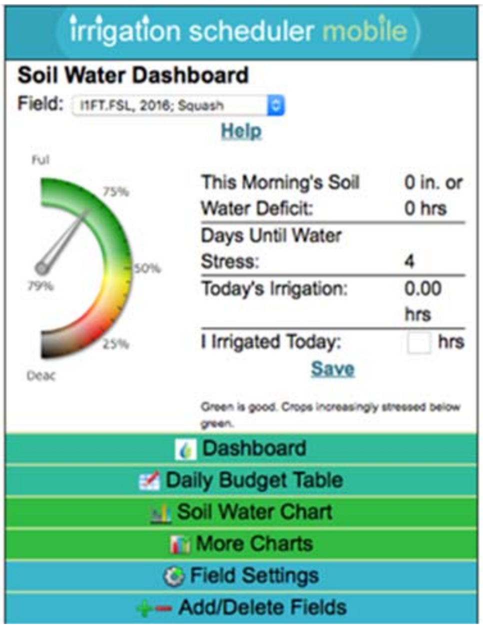
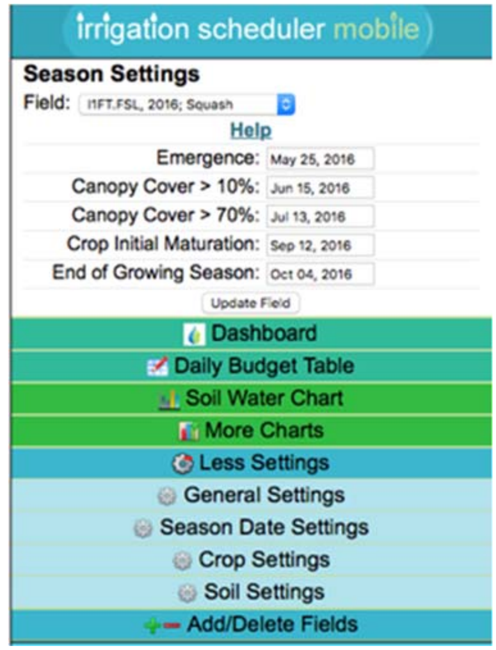


Figure 10. Crop maturity events can be update throughout the season



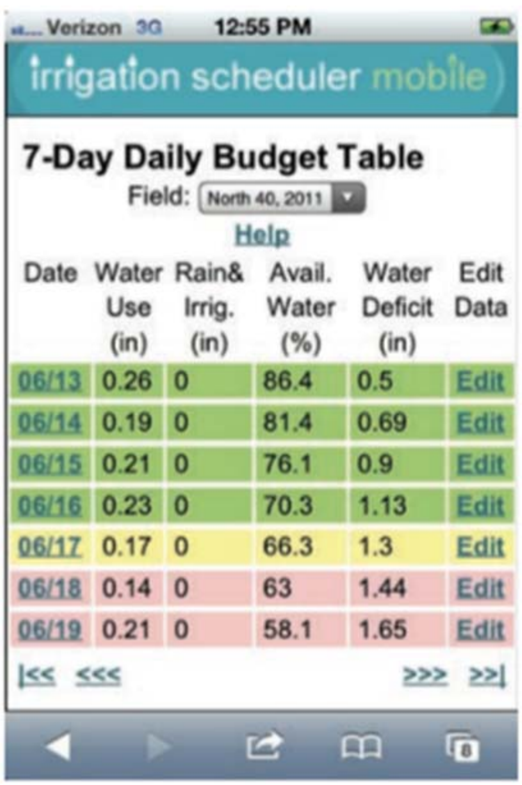


Figure 11. Daily budget table view to track weekly history. Red indicates MAD level has been breached. Yellow indicates soil moisture is nearing MAD trigger and recommended irrigation based off of weather forcast.

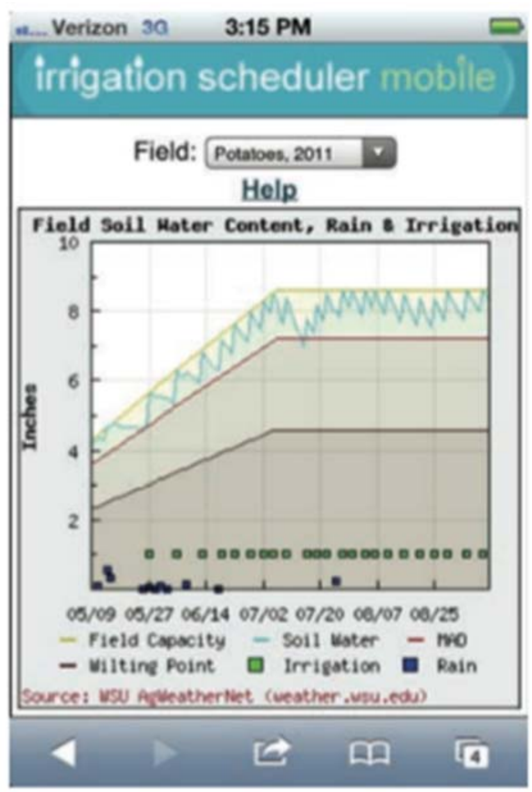


Figure 12. "Chart view" of entire season 's soil moisture history. Irrigation and Rain events indicated (inches). FC, MAD, and PWP given for reference.

Tips for accurate sensor use & placement

Figure 13. Decagon EM50G Logger with 5TE volumetric and temperature sensors.

Water content (volumetric) sensors are more useful for irrigation as they indicate both when and how much to apply. Multiple sensors at varying depths are useful to track moisture as rooting depth increases. Installing a sensor near the bottom of the root zone is beneficial to track over application – once water passes beyond the rooting depth it is lost to deep percolation.

- Multiple sensors can help account for variability in the field, values can be averaged if field receives uniform irrigation
- Avoid "wiggling" sensors during installation as created airspaces will increase variability of readings
- Install sensors in undisturbed soil (installing in the side or bottom of a hole). This ensures readings are similar to the overall field bulk density.
- Re-pack holes to the field bulk density to avoid creating preferential flow paths leading to inaccurate readings.
- Accelerated moisture loss (below field capacity) in sensors readings indicates the presence of root uptake at that depth.
- Sensor types are discussed with more detail in WSU extension fact sheet FS083E "Practical Use of Soil Moisture Sensors and Their Data for Irrigation Scheduling".

Recommended installation depths:

1 sensor: Middle of the root zone (half of total rooting depth)
2 sensors: ¼ and ¾ of the root zone.
3 sensors: First sensor at 4-6 inches, second at ½ to ⅔ of root zone, and last near the bottom of root zone.

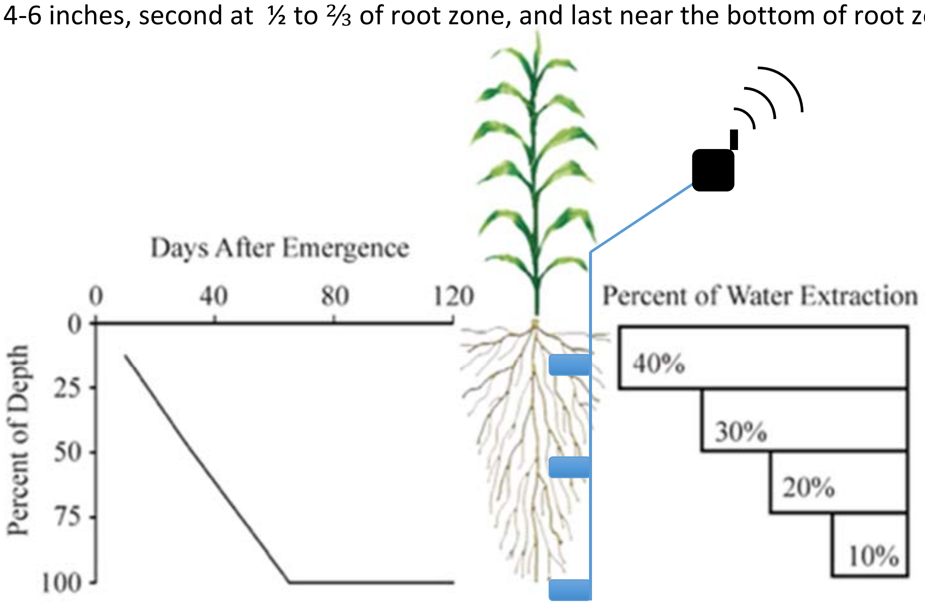


Figure 12. Example triple sensor placement and idealized root zone soil water extraction with corn root development patterns.

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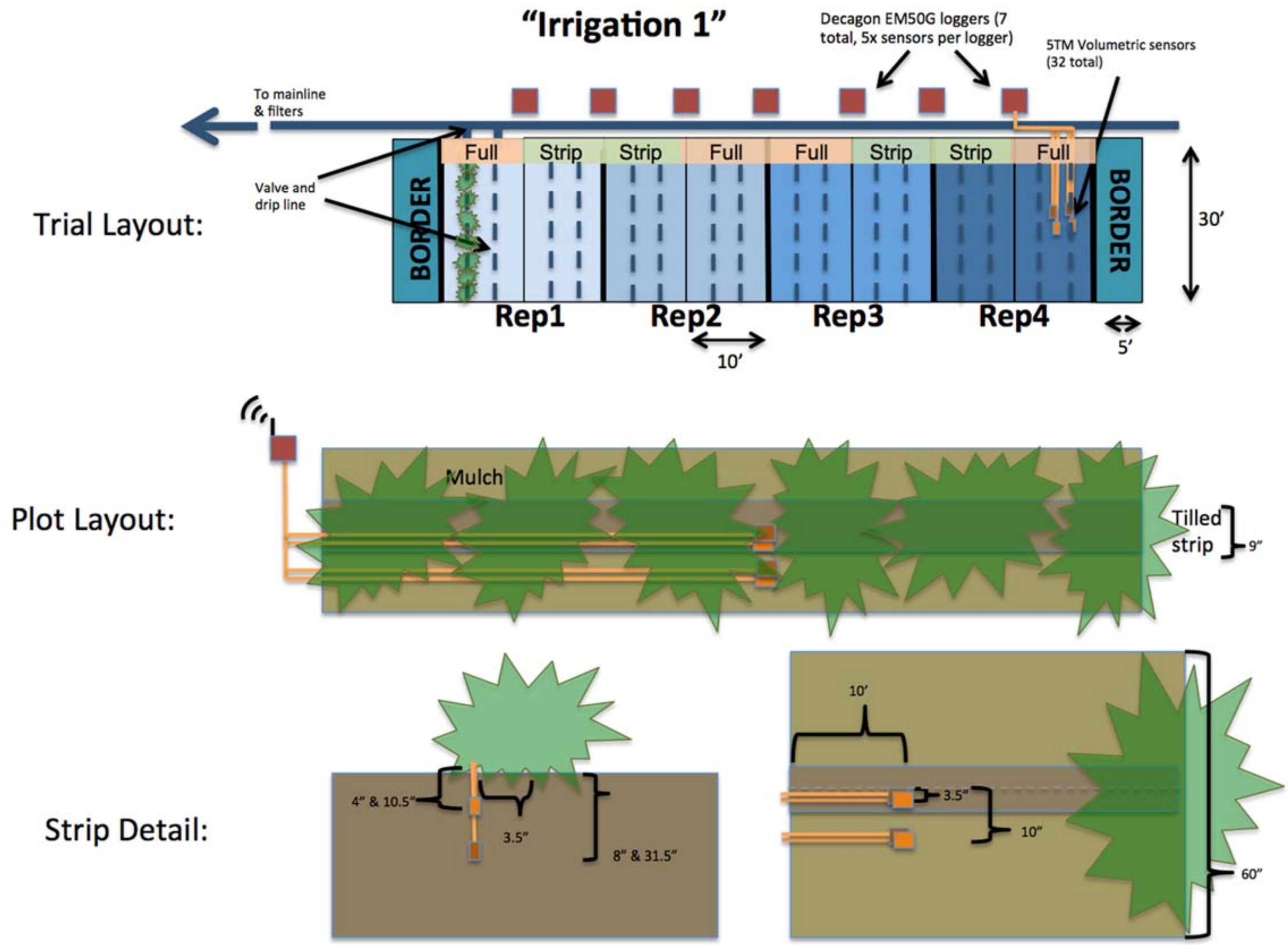
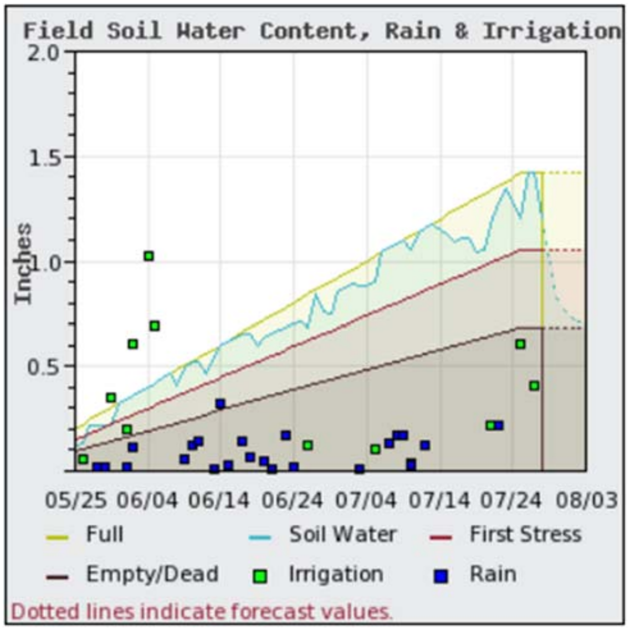
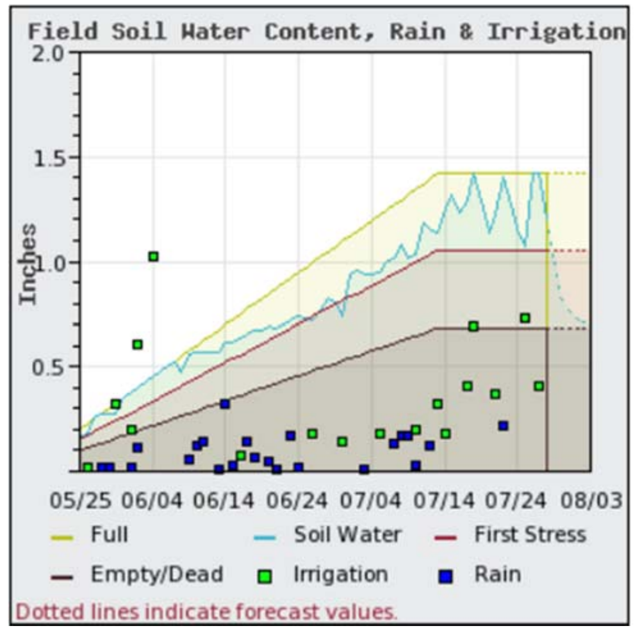
Strip Tillage and Cover Cropping for Enhanced Water Use Efficiency in Western Washington Organic Vegetable Farms



<u>Project Description</u> "Irrigation1" investigates if high residue strip till (ST) systems (using a fall planted rye cover crop) can improve water use efficiency, or "crop per drop" by investigating the water dynamics of a flailed mulch layer in comparison to bare ground full tillage (FT) systems. Both the strip till and full till treatments are planted to a fall rye cover crop that is flail mowed in the spring prior to transplanting winter squash. A modified Maschio multivator is used for strip tillage and an Imants rotary spader is used for the full-tillage treatment. Treatments receive separate irrigation schedules based off water content sensors within the root zone. Sensors are initially placed at 4" and 8", and as rooting depth increases (as tracked by irrigation model), they are then re-installed at 10.5" and 31.5". Water content is then used with WSU's AgWeathernet (AWN) irrigation scheduler model to determine daily application rate.

2016 Findings: The first season provided a great learning opportunity monitoring soil moisture via sensors and using the AWN irrigation scheduler. Crop growth in the ST plots has lagged behind the FT treatment with FT reaching 70% canopy coverage on July 13th vs. ST on July 25th. Mid season soil nitrate tests show that this would not be caused by lack of nitrogen, and soil water has been relatively higher in the ST plots. Temperature has been consistently lower in ST than FT throughout the growing season, which could have led to reduced root vigor and a reduction in overall plant growth. Soil moisture in the FT plots has been generally lower this season requiring a higher frequency of applied irrigation.





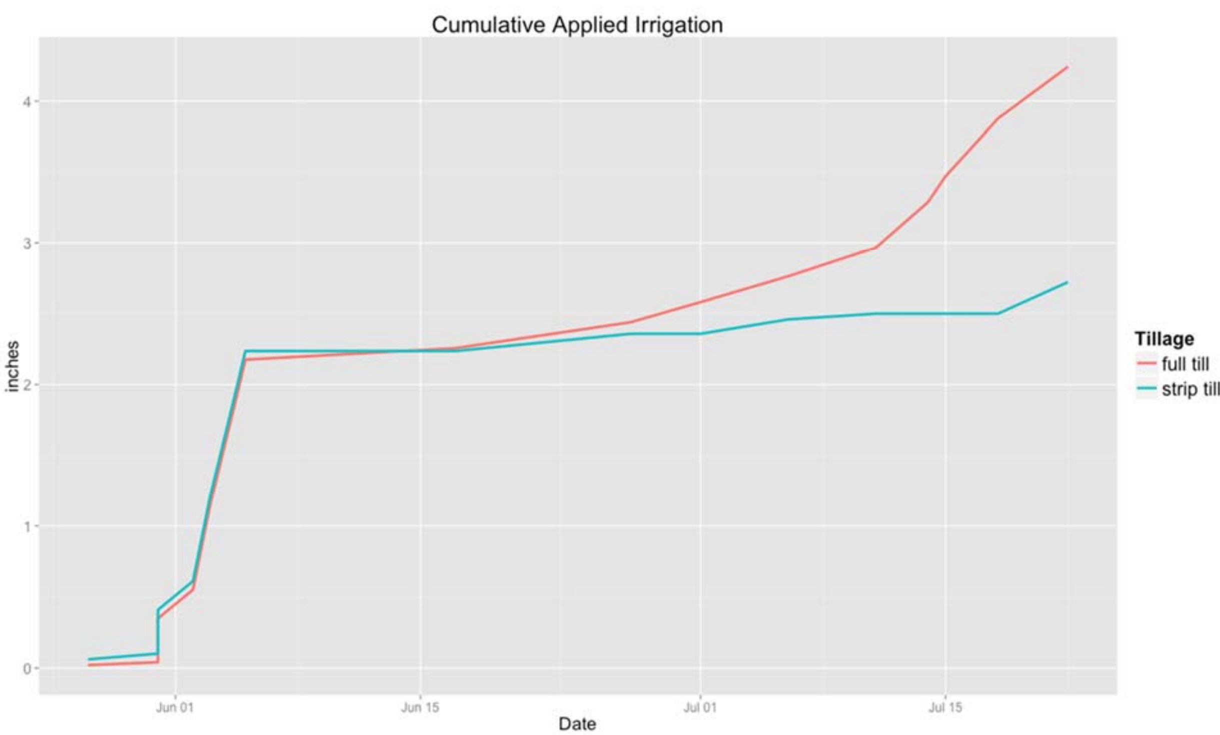


Figure 5. Cumulative Irrigation use between tillage types

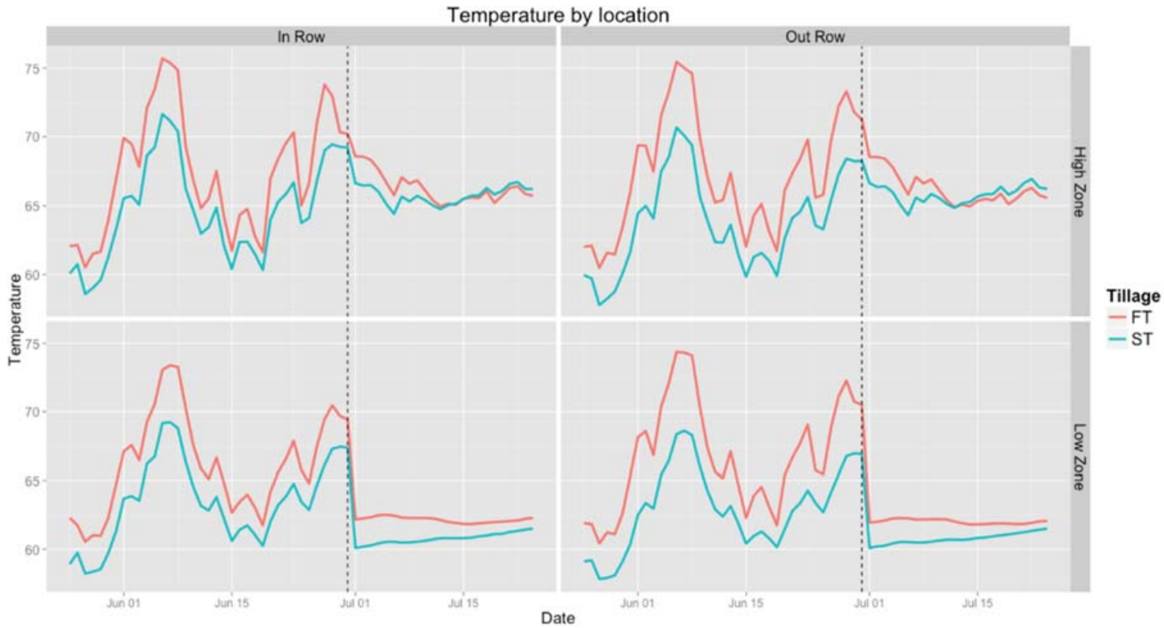


Figure 6. Crop development and resulting water use during a growing season. In Row = 3.5" away from plant. Out Row = 10" away from plant. Dotted line indicates sensor depth increased from 4" to 10.5" ("High Zone), and 8" to 31.5" (Low Zone).

Figure 7. Soil temperature by tillage type at various locations in field. In Row = 3.5" away from plant. Out Row = 10" away from plant. Dotted line indicates sensor depth increased from 4" to 10.5" ("High Zone), and 8" to 31.5" (Low Zone).

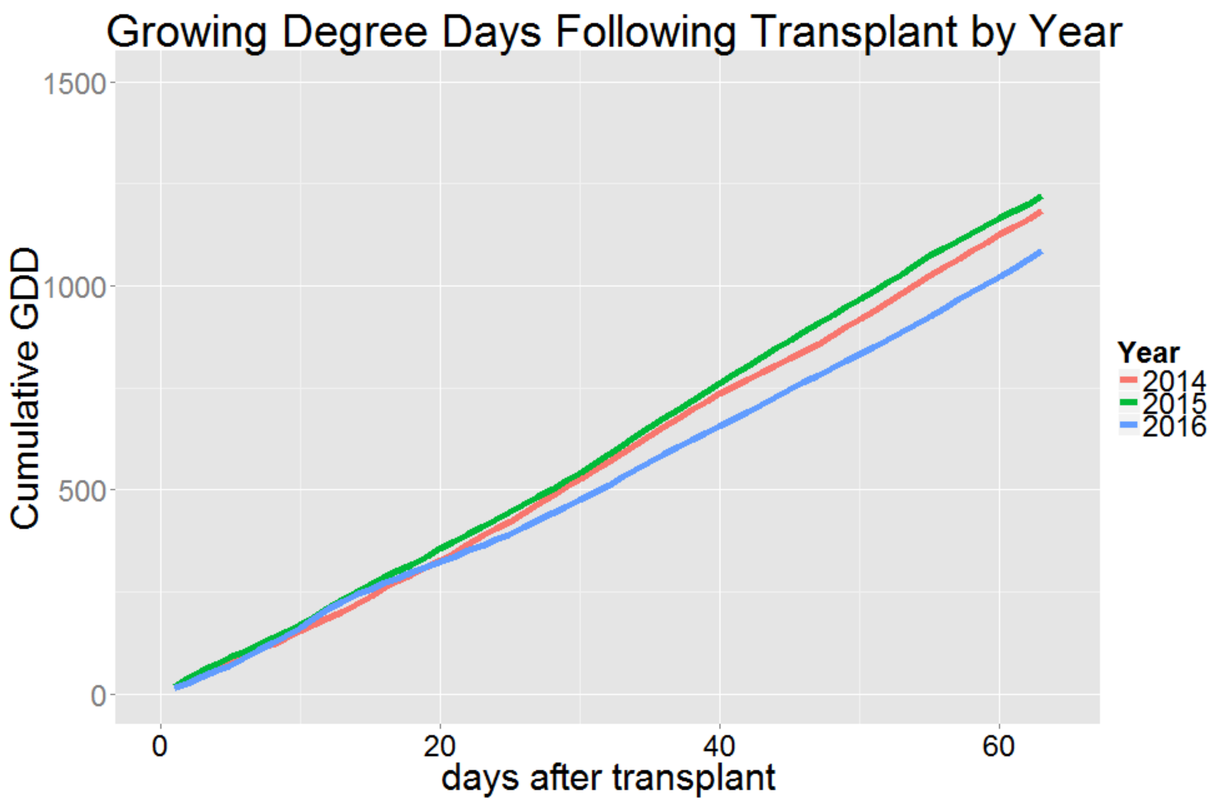


Figure 8: Growing degree days accumulated since squash transplant in 2014, 2015, and 2016. Transplant dates were 9 June 2014, 26 May 2015, and 25 May 2016.

Multi-year Weed Management and Transitioning to Reduced Tillage

Chris Benedict, Agriculture and Natural Resources Faculty, WSU Whatcom County Extension

Background Information

Annual Weeds – Emerge from the soil, produce seed and die in a single season (less than one year). There are two major types, winter and summer annuals.

Winter – begin growth in the late summer/early fall and produce seed the following spring.

Summer – emerge in spring and produce seed before the fall.

NOTE: Because of mild temperatures in western Washington some weeds classified as winter annuals can act similarly to summer annuals in terms of life cycle.

Biennial Weeds – These plants have a two-year life cycle. They emerge from seed and grow vegetatively the first year, then produce seed the following year.

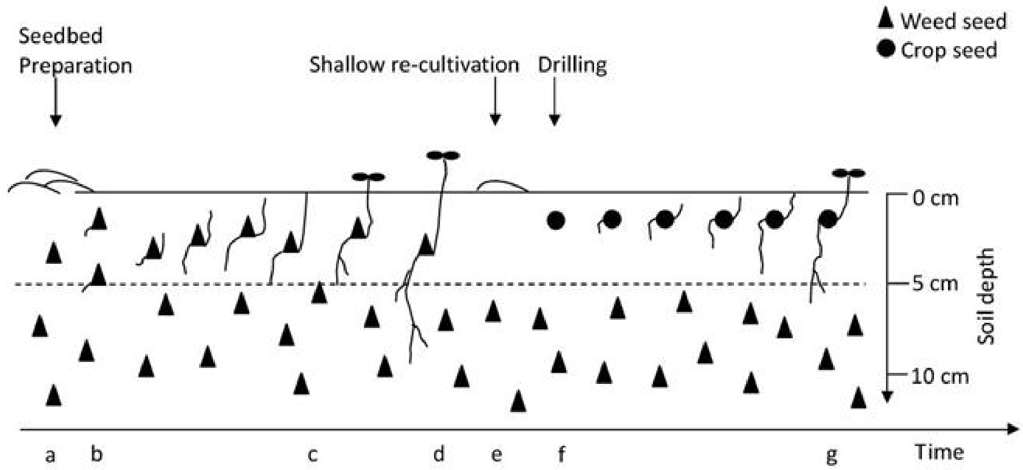
Perennial Weeds – Plants that live more than two years and reproduce through asexual (vegetative) or sexually (seed). Simple perennials typically spread by seed, while creeping perennials spread via rhizomes, stolons etc.

Common Weeds in Reduced Tillage Trials, 2009 – 2016.

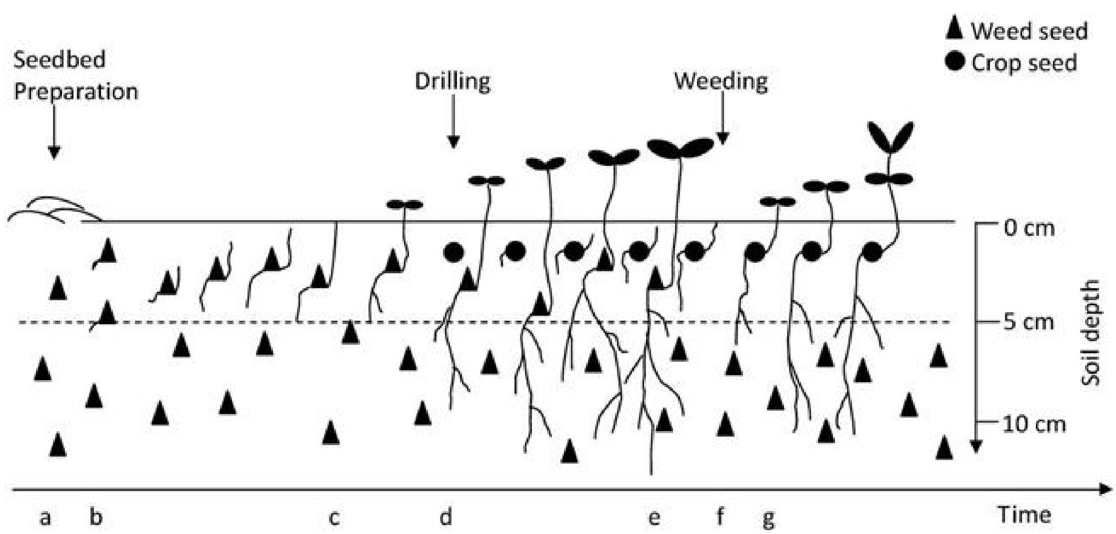
Summer annuals	Winter annuals	Biennials	Simple perennials	Creeping perennials
Corn Spurry	Henbit	Wild Carrot	Dock sp.	Field Horsetail
Horsweed/marestail	Shepardspurse		Common Dandelion	Quackgrass
Common Lambsquarters	Mustard sp.*		Field Bindweed	Canada Thistle
Redroot Pigweed	Chickweeds*			Yellow Nutsedge
Black Nightshade	Field Pennycress			
Hairy Nightshade	Annual Sowthistle			
Purple Deadnettle*	Common Groundsel*			
Common Purslane*				

*Can act as both Winter/Summer annual

False seed bed - For false seedbeds the seedbed is prepared ready for planting, (a), non-dormant weed seeds in the top 2" of soil germinate (b-c) and then emerge (c-d), seedlings are killed by tillage (e), the crop is then sown or planted (f) crop germinates and emerges (g).



Stale seed bed - For stale seedbeds, the seedbed is prepared the same as for false seedbeds (a), non-dormant weed seeds in top 2" of soil germinate (b-c), the crop is sown (d), weed seedlings emerge (c-e), immediately prior to crop emergence (g) weed seedlings are killed without disturbing the soil (f), crop emerges (g).



Summer fallow cultivation – Consists of a fallow summer where tillage is repeated every 7-10 days. This is typically done with a primary or secondary tillage tool. Over time the tillage depth should progressively become shallower so that weed seed is not homogenized within the seedbank profile. This tactic is effective in fields with creeping perennials or fields with heavy annual weed pressure.

Advantages of Reduced Tillage Systems for Managing Weeds

Overwintering Cover Crops

Central to a RT system is the use of overwintering cover crops. A solid stand of cover crops will compete with winter annuals, biennials, and perennial weeds depending on field preparation method and seeding timing.

Cover Crop Mulching Effect

Terminated cover crop biomass can prevent germination through shading and cool soil temperatures. Additionally, residue could influence soil moisture thus impacting germination incidence and rates.

Impact Weed Seed Bank

RT systems can increase weed seed decay and predation from insects. True no till systems increase weed seed in the shallow portions of the seedbank, but annual reduced tillage systems allow for burial of weed seed in years of high seed input. Vertical movement of weed seed is impacted by tillage operations.

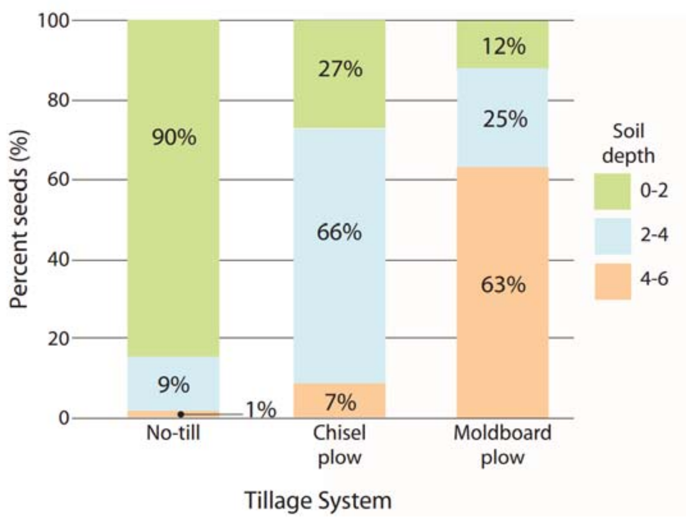


Figure 1. The vertical distribution of weed seeds in the soil profile at depths of 0 to 2 inches, 2 to 4 inches, and 4 to 6 inches (Source: Shrestha et al., 2006; Adapted from Clements et al., 1996).

Impact Light Sensitive Weed Species

Several weed species are sensitive to flashes of light entering the soil profile. RT systems reduce the amount of tillage activities and thus light entering into the soil profile. Without this cue, several weed species present in western Washington will not germinate.

Disadvantages of Reduced Tillage Systems for Managing Weeds

Loss of Tillage as Weed Management Tool

Tillage prior to seeding or transplanting eliminates established and germinating weeds. Newly seeded crops or transplants are at the their most venerable stage for competition from weeds and by placing them into a competitive environment can result in lowered yields and yield quality.

Requires Specialized Cultivation Equipment
In-season mechanical cultivation is an effective tool for organic farmers and many of these tools are not compatible with high residue RT systems. There are several high residue tools on the market, but are an added cost and are not effective for all weed species or situations.

Other Notable Facts of Reduced Tillage Systems for Managing Weeds

Shifts in Weed Species
Researchers across the country have documented shifts in species dominance when adopting a RT system. Though there has been no clear pattern across various sites. In research performed in western Washington we have witnessed a pattern of dominance shifting towards winter annuals, biennials and perennial species across years in RT systems.

Weed Characteristics That Makes a Field a Candidate for Reduce Tillage Systems

Assessing the use of a RT system in a field or bed should be based on the history of weed pressure, the species present, and distribution within the field.

Weed Life Cycle Assessment

Dominant Weeds	
Annuals	○ Winter annuals can survive spring cover crop termination methods in RT systems. ○ Summer annuals are typically suppressed/delayed by RT systems. ○ Seed survival within the seedbank is species dependent. *Tip: Rotational RT can draw down the annual seedbank.*
Biennials/Simple Perennials	○ Biennials can effectively survive cover crop termination methods (e.g. mowing). ○ Biennials and simple perennials can survive undercutting cultivation. *Tip: In fields with historical biennial or simple perennial species full tillage should occur every other year.*
Creeping Perennials	○ Thrive in environments without disturbance and survive mowing activities. ○ Once established tillage equipment can spread vegetative propagules. *Tip: Use of RT in fields with creeping perennials should be avoided, but utilizing a summer fallow cultivation tactic can help.*

Setting Up a Field for RT System Success

Prevent Seed Production

Preventing weed seed production is the first practical step towards RT success (or any farming!). If weeds escape your weed management strategies, spend the extra time to remove seed heads and dispose of outside of your fields.

Follow a Competitive or Short-Term Crop

Competitive crops can suppress weed emergence and survival. Short–term crops don't allow weeds to become established and break their life cycle. Competitive crops include sweet corn or squash while short term crops include radishes or green onions.

Reduce Weed Seeds in the Seedbank

Several strategies can be used to reduce the weed seedbank and include:

Cover Crop Fallow – Taking a field or bed out of production for a year and cover cropping with cool- and warm-season cover crops with no bare ground periods provides a competitive environment for weeds.

Stale Seed Bed – Described above.

False Seed Bed – Described above.

Eliminate Vegetative Perennial Parts

If biennials or perennials have become established in a field or bed take the time to effectively manage them. The overall goal is to **prevent movement of carbohydrates down into the roots**. Also known as Summer Fallow Cultivation this tactic can be accomplished by tilling (or close mowing) every seven to ten days until emergence ends. This will take time and persistence!