Rotation Planning & Tillage Strategies for Soil Health

Intros

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Minimising tillage for field scale horticulture

Reasons for tillage in Organic systems

- Tillage management plays a key role in SOM turnover providing suitable soil structure and conditions for mineralizing nutrients, particularly N
- Tillage also facilitates seedbed preparation, improving conditions for rooting and nutrient uptake
- Tillage is crucial for the control of weeds in organic farming. Weeds are one of the most important factors limiting organic crop production.

Tillage in Rotations

- A. **Post harvest cultivation** : This consists of shallow operations carried out shortly after the harvest to clear the field of weeds and crop residue and to restore the soil structure. This group also includes tillage during fallow periods (for water conservation, weed control and improvement of the soil structure and fertility).

- B. **Main (primary) tillage**: Deep operations which are performed during the period between two crops to control weerestore the soil structure, prepare the land for seedbed preparation.

- C**. Seedbed preparation**: Shallow operations are intended to prepare a seedbed or make the soil suitable for (trans)planting. They include weed control and structural improvement for germination and early growth.

- D. **Crop management tillage operations**. These are very shallow operations controlling weeds, breaking up surface crusts to improve water infiltration and crop emergence and for forming ridges which encourage early growth and facilitate the harvesting of root crops

Brief rational for reducing tillage

Negative effects of tillage

- Decreases in biological activity an biodiversity
- Increases in soil erosion
- Losses in organic matter content
- Destruction of soil physical structure due to frequent machine traffic and tillage activities on the field

Reducing tillage can mitigate the negative effects but also:

- Reduce labour
- energy consumption suppress pathogens
- Higher macro porosity
- Increase organic matter
- Reduce inputs he input such as water (irrigation), fertilizers
- Increase Fungal biomass
- Higher ratio of fungi to bacteria
- Increase in rhizosphere interactions
- increase in plant health
- better soil structure through increased rooting and aggregation
- better water infiltration and soil water retention and earlier field access
- Increase earthworm populations

Trade offs in reducing tillage

- **Topsoil compaction** strongly dependent on soil type and climate. Unstable soil with low organic matter content and greater soil moisture may increase soil compaction, possibly leading to the greater emphasis on soil structure issues
- **Lower yields**; Reducing tillage intensity in organic systems reduced crop yields by an average of 7.6 % relative to deep inversion tillage.
- **Weeds** were consistently higher, by about 50 %, when tillage intensity was reduced, although this did not always result in reduced yields.
- **N2O emissions** may increase under reduced tillage counteracting increases in SOC.

Shallow plough

- Shallow ploughing to no more than 10 cm as to not mix layers of soil communities
- Specialist plough needed
- Effective at terminating cover crops and controlling weeds
- Good for producing seed be preparation

Deep /strip and zone-tillage

Cultivating strips often around 30cm

Additional deep ‘shank’ can be used to ameliorate compaction and aerates soil.

Living cover crops or mulches can be left in uncultivated strips and controlled by mowing or undercutting

Many benefits from reducing overall area cultivated but still stimulating mineralisation and controlling weeds

Non inversion tillage

Often spring tines or duck feet cultivators will be used in conjunction with spring tines or cage roller to produce seed bed and primary tillage. (i.e chisel plough)

Permenant bed systems

Reducing and Alleviating compaction

Best option is to control and reduce compaction by careful management and standardising systems.

Controlled traffic systems can improve soil physical properties, and 20–60% fewer tillage operations, compared to conventional production systems.

Controlled traffic systems on Scotland have displayed an increase in total (14%) and marketable (18%) yield for potatoes . In the Netherlands increases, such as 10% for onions and 35% for spinach have also been seen.

Weed control

Brush/ cage weeders

Finger weeders

Steerage hoeing

Spring tined harrow

Flame weeding

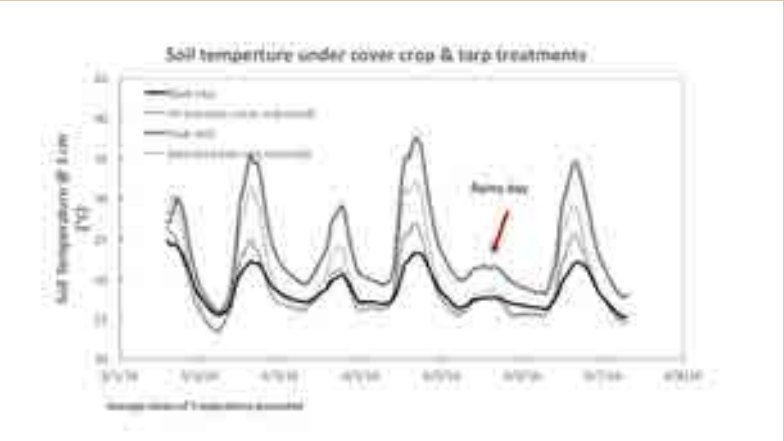
Undersowing

white clover as the legume species providing the best compromise between competing with weeds while limiting the competition for light

In situ mulching

- These strategies, in addition to limiting soil disturbance
- and suppressing weeds, also provides an opportunity to address another principle of conservation
- agriculture by improving living soil cover.
- increase water infiltration, and preserve soil moisture
- Multiple rollings to terminate
- **Choice of relevant cover crop species:**

Plastic mulching



Cut and mulch

High residue transplanters

HIGH RESIDUE DRILLS

Mowing

Grazing

- Compared with mowing, sheep grazing did not affect soil chemistry, temperature or moisture. Our study demonstrates that sheep grazing removed more cover crop biomass than mowing at termination.
- BUT cash-crop yields did not differ between previously grazed and previously mowed plots in the subsequent growing season.
- Integrating sheep grazing into market garden operations could make cover crops more economically viable without having adverse effects on subsequent cash crops.

Points to consider

The success of conservation tillage in organic farming hinges on the choice of crop rotation to ensure weed and disease control.

Rotation of tillage type according to crop type, in conjunction with compaction control measures is required

Suitable cover crop mixtures are key

A high standard of management is required, tailored to local soil and site conditions

Soil Health for Growers

Evidencing Soil Health in UK Cropping Systems

Grass Margin Comparison

Soil Structure

A measure of soil health

Poor Soil Structure

- Blocky, platey, angular, consolidated, heavy, dense, solid, cracked
- Forked roots
- Homogenous/uniform
- VESS

What is Good Soil Like?

Good Soil Structure

- Crumbly, friable, well structured
- Rounded, bobbly
- Uncompacted – no branched roots
- Workable, Forgiving
- Free draining, water retentive
- Heterogeneous/non-uniform
- VESS

Aggregation

Master Indicator of Soil Health

Aggregation, the Master Indicator

Aggregation

Tests: Infiltration Rate, Slake, Bulk Density

Soil Health Principles

- Insights:
  1. Microbes Matter
- Principles:
  1. Living Root – long as possible, as often as possible
  2. Covered Soil – by residues or living plants
  3. Minimise Disturbance – tillage/cultivation
  4. Diversity – in rotations or mixes
  5. Feed Soils – organisms need energy
  6. Incorporate Animals – ideally adaptive grazing
  7. Minimise Use of Chemicals/Synthetics

1. Living Root

1. Living Root

1. Living Root

'Rhizosheath'

1. Living Root

1. Living Root

2. Covered Soil

Rainfall simulator

2. Covered Soil & Living Root

Straw-mulched Elephant Garlic

3. Minimise Disturbance

Slake Test

3. Minimise Disturbance

Slake Test: No-Till – Till - Forest

4. Diversity – Cover Crops

- Cocktail Cover Crop
- Age: 2 months
- Probe Depth: ~35cm
- Spading Ease: 5 - Very easy
- VESS (Low is Better): ~1.5
- Nodules: N/A
- Seed Mix: Cotswold Seeds

- Red Clover Green Manure
- Age: 12 months
- Probe Depth: ~15cm
- Spading Ease: 1 -Very Hard
- VESS: ~3.5
- Nodules: 1- Low/None

4. Diversity – Cover Crops

4. Diversity – Spring Cultivation

Cocktail Cover Crop

- Species: x11
- Diversity: High
- Seeds: Cotswold Seeds

Grazing Rye/Vetch

- Species: x2
- Diversity: Low

5. Feed Soils

What's happening here? What's not happening here?

5. Feed Soils

When there's no crop

7. Minimise Chemicals

- Undoes your good work

More Soil Health Indicators

Soil Health Indicators

Tilled Soil – "Sticky Soil" (Score: 1)

Soil Health Indicators

Woodland Soil – "Sticky Soil" (Score: 3)

Soil Health Indicators

Woodland Soil - Air bubbles, Heterogeneous, Light

Soil Health Indicators

Tilled Soil – Platey, Cracked. Heavy

Soil Health Indicators

Arable	Lawn	Hedge & Lawn
Spading: 1 (zero)	Spading: 3	Spading: 4
Colour: Mid, Red	Colour: Mid, Orange	Colour: Dark, Brown

W hat it looks like

No-Dig Market Garden

Green-waste mulch system

No-Dig, Compost Mulch Hort

Green-waste mulch system

High Diversity Cash Crop Hort

High Diversity Cash Crop Hort

- Hay mulch, no-dig system

Soil Health Practices

Conclusions

- Most of the soil health principles were born out in ongoing observations
- Aggregation correlates with soil health practices
- Data gathering – Sectormentor for Soils
  - Makes my life so much simpler
- Trials are the best way to implement these techniques and measures

Cover Crop Selection Exercise

Turn to your neighbour

Fill-out sheets – 1 to 5. Total up results

Rank the options – Top 3

Rotation Planning Exercise

Clover Leys CC1

Short term plantings of perennial clovers/legumes, typically with a rye grass. Regularly topped, to encourage new growth and prevent seeding. Can fix nitrogen, check for nodules. Typically tilled-in or incorporated after 6-12+ months. Deep roots condition soil for subsequent cash crop plantings. Residues will be mineralised in short period, feeding cash crops but not contributing to soil organic matter, long term. Weed seed can be present in seed mixes.

Herbal Leys CC2

Diverse, long-term mixes, containing deep rooting perennial- grasses, herbs and clovers. Builds soil and improves structure. Drought resistant. Supports pollinators and birds. Suits grazing and organic mixed operations. Typically left-in for 2-4 years, to get the most out of slower growing plants. Destruction in organic systems only possible with cultivation. Seed can be expensive. Careful establishment is essencial. Where drilled allow seeding in first year to fill-out bare patches at base of sward.

Successional Cover Crops CC3

2-year continuous (successional) cover crop planting. Spring-sown cereal rye, sweet clover & other annuals. The stand is mob grazed ("trample grazed") or crushed in autumn, when rye is mature, leaving a deep mulch over winter. Sweet clover grows on into second year, where finally termination by tilling all of- or strip-tilling half of the sweet clover and interplanting with row crops (eg bush courgettes). Builds soil, improves structure & makes a significant contribution to soil organic matter. Source: Mark Shepard (Wisconsin).

Cocktail Cover Crops CC4

Diverse spring-sown annual mixes. Contains warm season grasses/broadleaves. 10 or more varieties is advised. Plants build soil, improve structure & smother weeds. Residues protect soil, feed soil life & suppress weeds. Destroyed when fully mature, ideally by rolling or mob grazing, leaving a deep residue of litter. Builds soil & soil structure. Improves water holding capacity & infiltration. Root exudates create new soil organic matter (SOM), residues feed soil organisms. Source: Gabe Brown (N. Dakota).

Short-Term Cover Crop CC5

Very fast-growing annual plants sowed as straights or in mixes. Can mature in as little as 8-12 weeks. Phacelia, buckwheat, mustard, radish are all possible options. Best sown in spring or summer. But may be overwintered if necessary. Phacelia/ buckwheat mow-kill easily. All can be crimped/ rolled, when fully mature for no-till systems. Mustard/radish are cheap seed but may cause issues in rotations with brassica crops. Sow densely for best results.

Cereal Rye Cover Crop CC6

Year-long sowing of cereal. Can be combined with a legume eg vetch or pea (which uses the straw as a tutor). Cereal rye is selected for its vigour and long straw/bulk (any cereal is possible). Can be sowed late autumn, though will give better cover if sown in Sept. or earlier. Destroy by tillage in spring or when mature by rolling in late June/early July. When rolled, it will leave a deep residue or mulch that will have a low weed burden and can be planted into, direct. Vetches do not roll reliably. Spring-sowing for autumn-kill is possible.

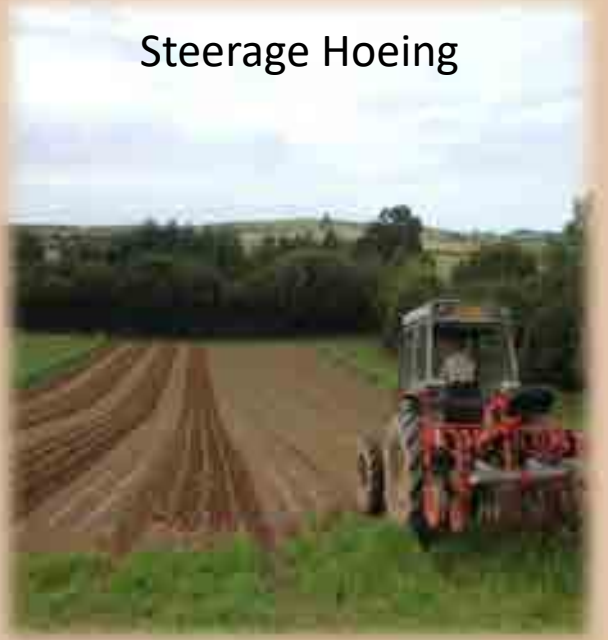
Bio-Mulching

Tined Harrrow

Undersowing and Intercropping

Plastic Mulching

Steerage Hoeing



Mowing

Plastic or bio Mulching

Suggested Practices – Management

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Sectormentor for Soils - Website

1.0 VESS

1.1 Earthworm Count

1.2 Slake

1.3 Infiltration Rate

1.4 Legume Nodules

1.4 Rhizosheaths

1.4 Spading Ease

1.5 Topsoil Depth

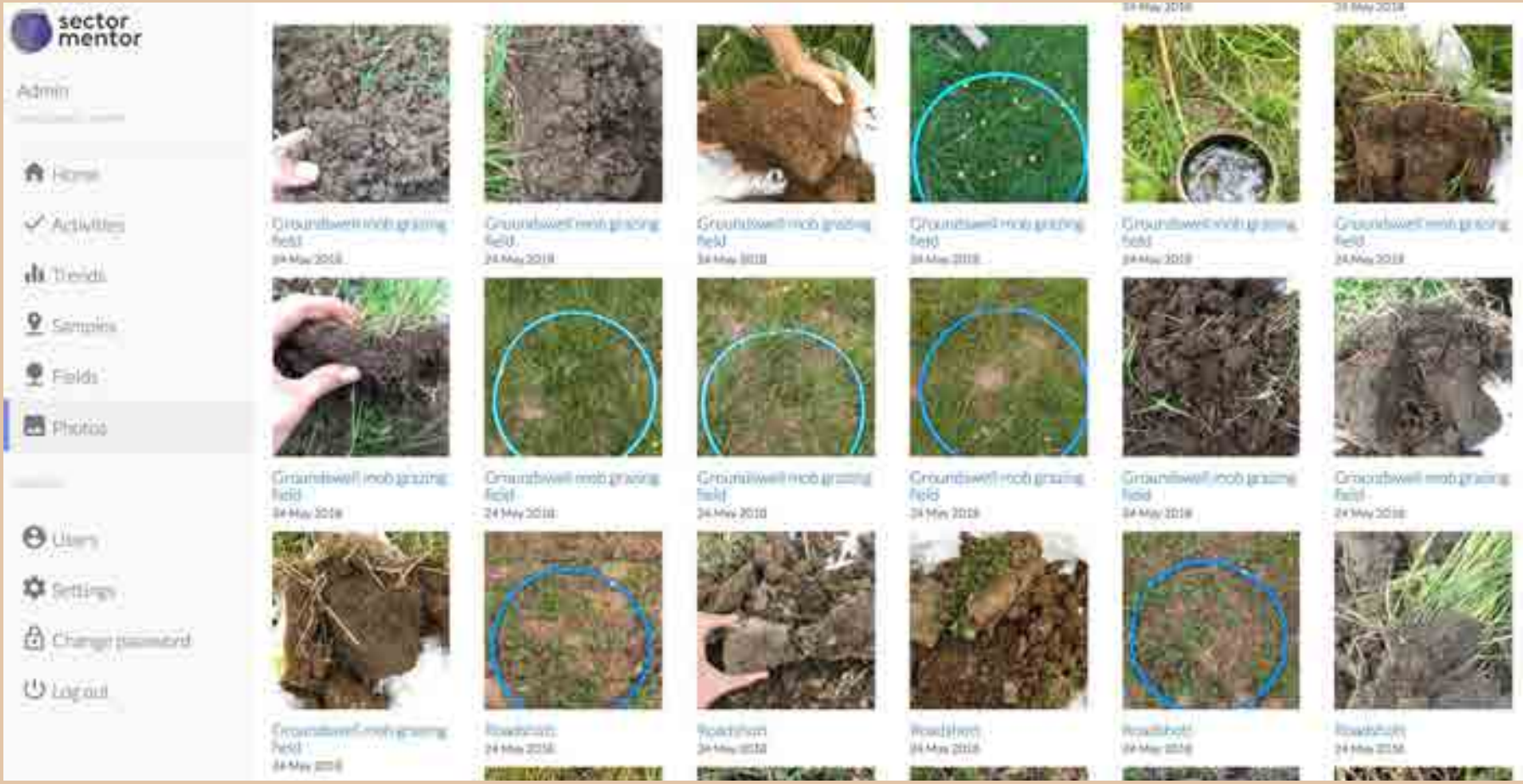
1.6 Probe Depth

2.0 % Broadleaf, Grasses, Undesirables Cover

2.0 Bare Soil

2.0 No. Broadleaf, Grass, Undesirable Species

Sectormentor for Soils - App



Take Homes

- "Roots Not Iron"
- Know your weeds
  - Observe & record
  - Where in rotation & when
- Use the SHPs to make decisions
- Cumulation of easy wins
- Experiment, trial & record

My Offering

- Advise for growers
- Help them to select novel practices
- Apply the soil health principles in the field
- Set-up trials
- Monitor & train in monitoring
- Rotation planning
  - info@nielscorfield.com

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