AHDB Strategic Farm Brassica Centre – East of Scotland Growers

Soil assessments September 2020

Background

East of Scotland Growers (ESG) have been experimenting with cover crops before their summer brassica crops. In spring 2020, ESG planted five different cover crop mixes in strips in their trial field near Balmullo, Cupar, Fife. The cover crops were sown on 14th April after harvest of energy beet on 12th March (in wet conditions) and destroyed just before planting broccoli on 2nd July. The cover crop mixes included Black oats, RAPS, Bodengare, Universal and Phacelia, planted in that order from the footpath on the North side of the field. Half of the cover crop area was destroyed by spraying with glyphosate one week before planting and the other half was destroyed with a crimper roller immediately prior to planting. The farm used strip till cultivation to plant the broccoli (Figure 1).

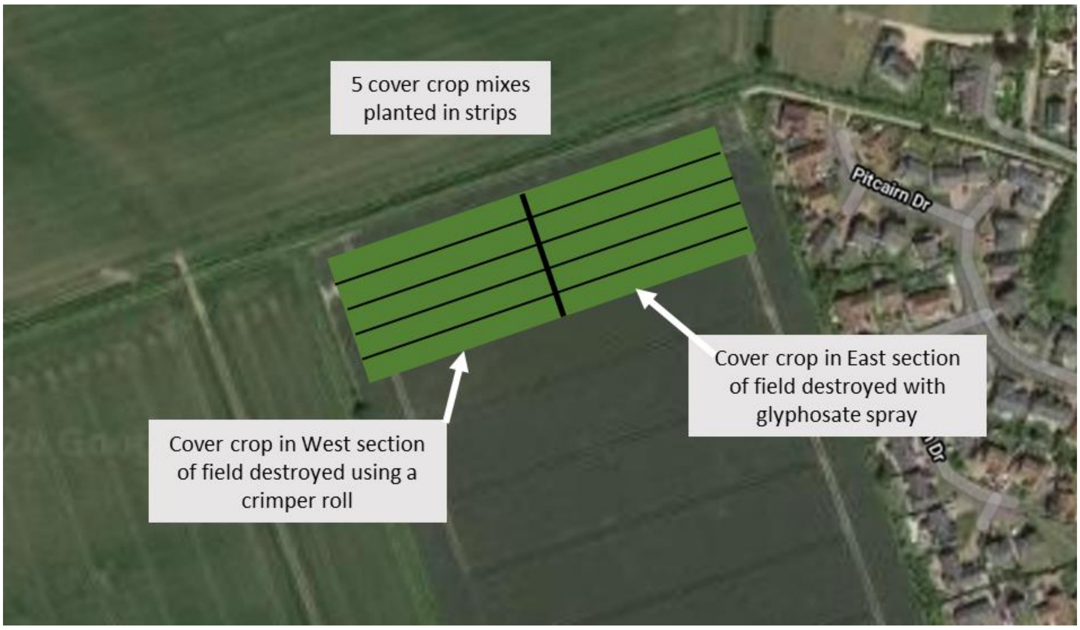

Figure 1. Layout of cover crop treatments in the ESG trial field at Balmullo.

After planting, the broccoli in the west section of the field, where the previous cover crop was destroyed using the crimper roll, grew better than the broccoli planted in the East section where the previous cover crop was destroyed using a glyphosate spray. This could be seen visually in the field and was shown in drone and satellite NVDI imagery of the field.

Objectives

The aim of this work was to:

i. Carry out soil assessments in the East (cover crop destroyed with glyphosate spray) and West (cover crop destroyed with crimper roll) sections of the field.
ii. Determine whether the difference in the growth seen in the broccoli crop between the East and West sections of the field can be related to underlying soil variability.

Soil sampling and assessments were carried out on 23rd September 2020.

Soil analysis

Three replicate topsoil (0-15 cm) samples were taken from each section of the field. Each section was divided into three blocks and one representative sample (25 cores per sample) was taken from each block. The soil samples were analysed for pH, extractable P, extractable K, extractable Mg, organic matter (by loss on ignition) and soil texture (% sand, silt and clay) by NRM laboratories, and for potentially mineralizable nitrogen (PMN) by Hillcourt lab (Table 1).

Table 1. Soil analysis results

	East section – cover crop destroyed with glyphosate spray				**West section – cover crop destroyed with crimper roll**			
	Rep 1	**Rep 2**	**Rep 3**	**Mean**	**Rep 1**	**Rep 2**	**Rep 3**	**Mean**
pH	6.3	6.1	6.8	**6.4**	6.8	6.3	6.3	**6.5**
Extractable P mg/l (Index)	33 (3)	37 (3)	37 (3)	**36 (3)**	34 (3)	37 (3)	32 (3)	**34 (3)**
Extractable K mg/l (Index)	208 (2+)	159 (2-)	152 (2-)	**173 (2-)**	134 (2-)	162 (2-)	159 (2-)	**152 (2-)**
Extractable Mg mg/l (Index)	181 (4)	189 (4)	188 (4)	**186 (4)**	149 (3)	158 (3)	168 (3)	**158 (3)**
Organic matter (%) LOI	3.6	3.7	3.7	**3.7**	3.5	3.5	3.5	**3.5**
Sand %	42	42	42	**42**	46	43	45	**45**
Silt %	37	36	37	**37**	35	37	36	**36**
Clay %	21	22	21	**21**	19	20	19	**19**
Texture	MCL	MCL	MCL	**MCL**	MCL	MCL	MCL	**MCL**
Potentially mineralizable N (mg/kg)	20	16	25	20	25	24	25	24

The soil is a medium clay loam with 3.5-3.7% organic matter. The target soil indices for vegetable rotations are pH 6.5, P index 3, K index 2+ and Mg index 2[1]. The soil is at the target index for pH and P, above target index for Mg (at index 3/4) and below target index for K (at index 2-).

Potentially mineralisable N (PMN) is the amount of organic N mineralised to plant available ammonium-N or nitrate-N when the soil is incubated to create conditions favourable for mineralisation. It provides an estimate of the amount of nitrogen from the breakdown of soil organic matter that is likely to become available to the crop during the season. PMN can also be used as an indicator of soil biological activity. Mean PMN in the East section of the field was 20 mg/k compared with 24 mg/kg in the West section. Both measurements are in the 'very low' range reported by Hillcourt laboratory (i.e. <27 mg/kg 'very low', 27-40 mg/kg 'low' and >40 mg/kg 'typical').

Overall the measurements suggest that there was no significant difference in soil texture and chemical properties between the east and west sections of the field.

Soil structure

Soil structure was assessed using the Visual Evaluation of Soil Structure (VESS) method and by digging a soil pit. The VESS score is an assessment of soil structure and porosity. The topsoil is assessed according to how easy it is to break-up a block of soil; the size and shape of its constituent soil structural units (or aggregates); the abundance of visual pores, cracks and fissures and the distribution of roots and earthworm channels. Three VESS assessments were made in each field section approximately equally spaced along the length of the field (Figure 2).

At each location, a 25 x 25 cm block of soil (approximately spade width and depth) was extracted, placed on a plastic tray and pulled apart by hand for assessment. The top 10 cm and bottom 15 cm layers were assessed and scored separately. The physical nature and visual appearance of the soil aggregates was compared with the pictures and descriptions on the VESS field sheet (Appendix 1). The lowest score (Sq1

[1] AHDB's Nutrient Management Guide (RB209) - Section 6 p.5 - Vegetables and bulbs

- Friable) is given to the least compact and most porous condition, and the highest score (Sq5 - Very compact) to topsoil that is difficult to break up into large, plate-shaped aggregates with roots mainly restricted to cracks. The number of earth worms in the 25 x 25 cm block of soil was counted.

Figure 2. Location of soil assessments (VESS and soil pit)

In both field sections, the top 10 cm soil layer scored Sq 2 'intact' – most soil aggregates were porous and easy to break with one hand. The bottom 10-25cm soil layer scored Sq3 'firm' – a mixture of porous aggregates and some angular less porous aggregates that are harder to break with one hand. With the exception of sample 1 in the East section of the field, the other five VESS samples scored very similarly (Table 2 and Figure 3).

Table 2. VESS results

	VESS Score		Number of earthworms
	Top 10 cm	Bottom 15 cm	
East section of field; previous cover crop destroyed with glyphosate spray			
Sample 1	2.5	3.5	5.0
Sample 2	2.0	3.0	3.0
Sample 3	2.0	3.0	4.0
Mean	**2.2**	**3.2**	**4.0**
West section of field; previous cover crop destroyed with crimper roll			
Sample 4	2.0	2.5	4.0
Sample 5	2.0	3.0	1.0
Sample 4	2.0	3.0	3.0
Mans	**2.0**	**2.8**	**2.7**

A mean of 4 earthworms per spade of soil was measured in the East section of the field and 3 earth worms per spade in the West section. This is a relatively low number of earthworms (Griffiths *et al.*, 2018) and probably reflects the dry soil conditions when the assessments were made as earthworms tend to burrow deeper into the soil when conditions are dry.

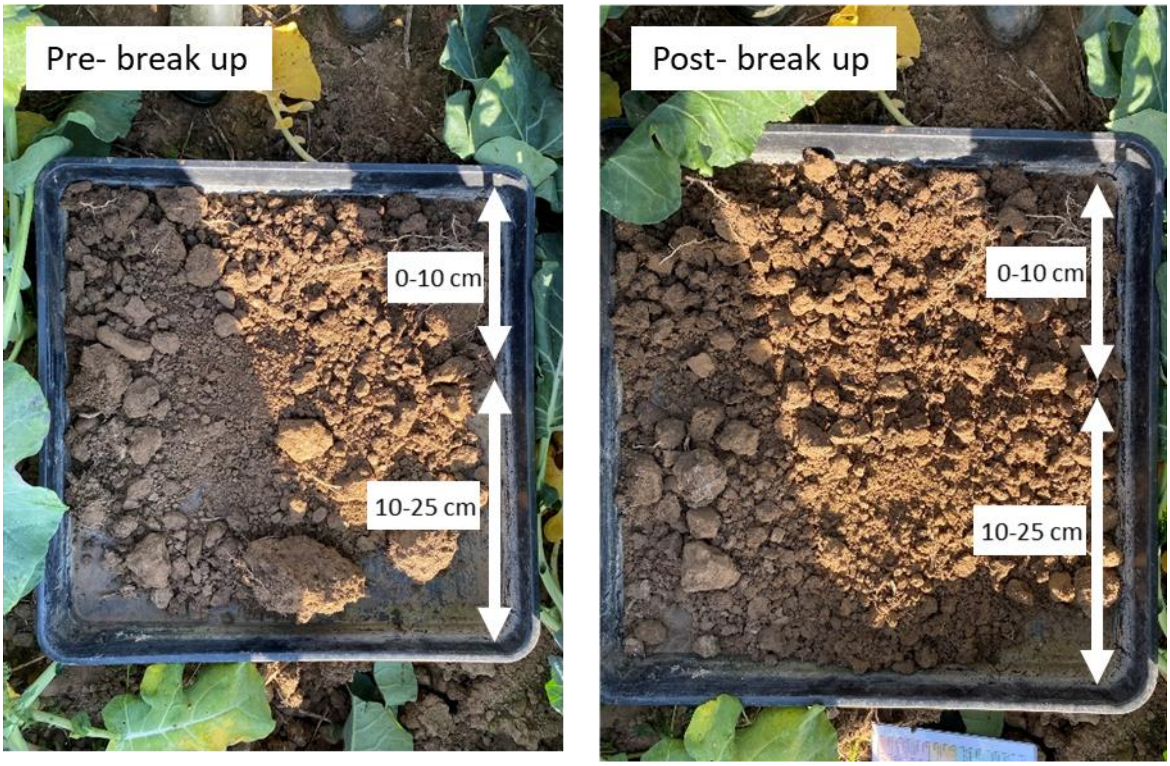

Figure 3. VESS sample 6 pre (left) and post (right) break up of soil; 0-10 cm layer scored Sq 2 'intact' and 10-25 cm layer scored Sq 3 'firm'

In addition to the VESS assessments, a soil pit was dug to approximately 50 cm depth at one location in the field to look at crop rooting. The broccoli roots were evident throughout the profile and there was no evidence of horizontal rooting which would indicate compaction.

Figure 3. Soil pit - broccoli roots were distributed throughout the soil profile

A video of showing soil assessments at the site can be viewed here.

Satellite NDVI imagery

Satellite NDVI imagery was sourced from DataFarming.com. Images with low cloud cover were selected to show:

- 2020 Broccoli crop (Figure 4a)
- 2020 spring/summer cover crop (Figure 4b)
- 2019/2020 previous energy beet crop (Figure 4c)
- 2019 previous energy beet crop (Figure 4d)

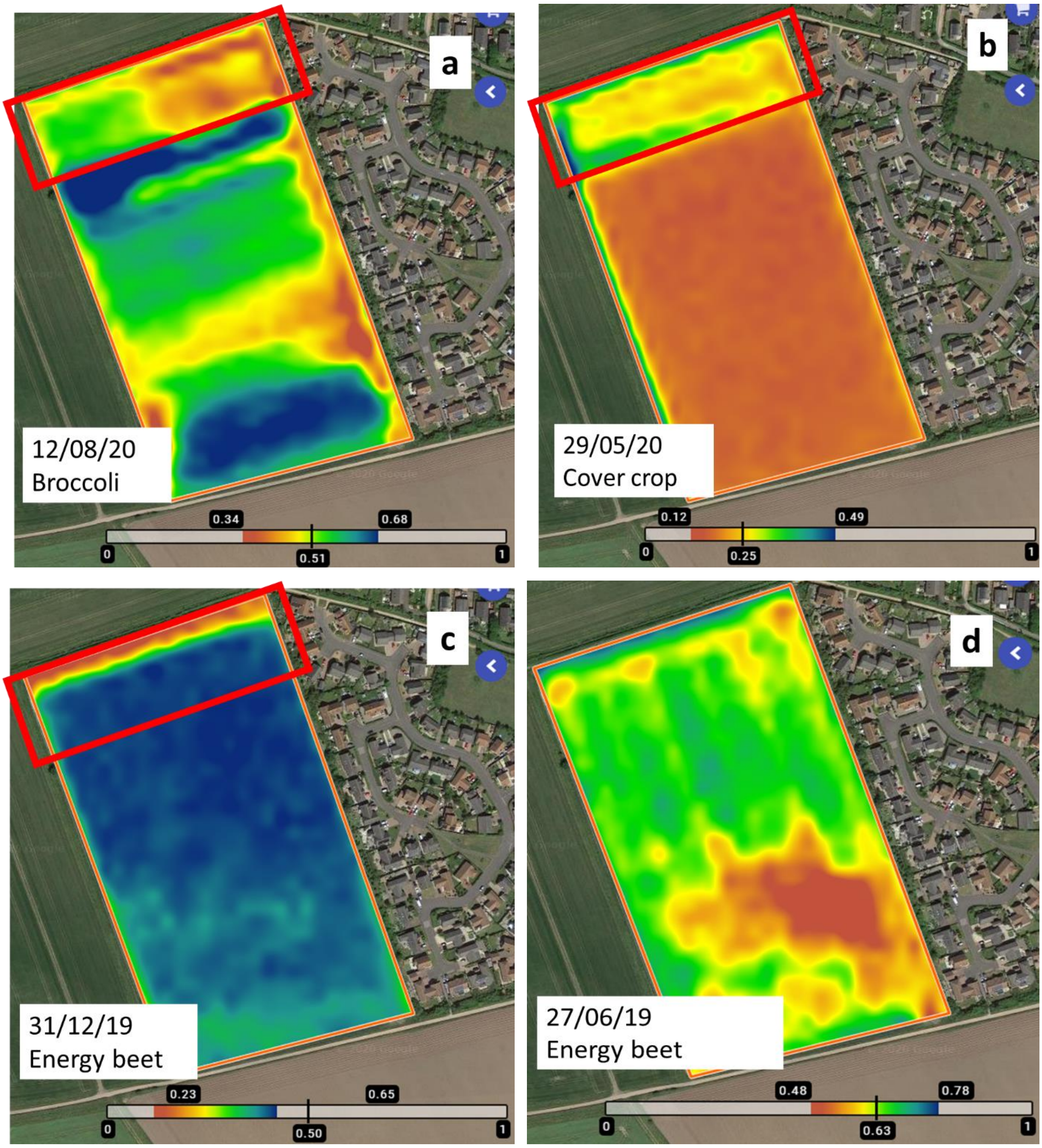

Figure 4. Satellite NVDI imagery showing current and previous crops – red box shows the area of the field planted with broccoli in 2020. ***Source – DataFarming.com, note that the colour scale used is not consistent between images.***

The NDVI image from 12/08/20 shows a clear difference in the broccoli crop, with lower NDVI in the East section of the field where the cover crop was destroyed with glyphosate. This East/West field difference is not evident in the NDVI images from the previous cover crop (Figure 4b), energy beet crop (Figure 4c or 4d).

Conclusions

The soil was at target index for pH and P, above target index for Mg (at index 3/4) and slightly below target index for K (at index 2-). Soil structural assessments did not identify any significant soil compaction or structural issues, despite the harvest of energy beet in March when soil conditions were wet, which could have caused compaction. Earthworm counts and potentially mineralizable nitrogen were measured as indicators of soil biology and were relatively low. The organic matter content (*c*.3.6%) is lower than average for a medium textured soil in lower rainfall area (Griffiths *et al.,* 2018). However, the good soil management practices employed by the farm including use of organic manures and cover cropping will help to maintain and improve soil condition over time.

There was no evidence that the East/West field difference seen in the 2020 broccoli crop was related to underlying soil variability. Soil laboratory analysis and physical assessments in the field showed that the soil was very similar in the East and West sections. Satellite and drone NDVI imagery show a clear East/West field difference in the broccoli crop which is in line with the split between the two cover crop destruction techniques (glyphosate spay and crimper roll). This supports ESG conclusion that the difference in broccoli crop performance is related to the cover crop destruction techniques, although not through any direct impact of the destruction techniques on measured soil properties.

Links and references

- AHDB Nutrient Management Guide Section 6 Vegetables & Bulbs
- Griffiths, B., Hargreaves, P., Bhogal, A. and Stockdale, E. (2018). Soil Biology and Soil Health Partnership Project 2: Selecting methods to measure soil health and soil biology and the development of a soil health scorecard. AHDB Final Report Number 91140002-02.
- SRUC Technical Note TN649 Fertiliser Recommendations for vegetables, minority arable crops and bulbs
- Visual Evaluation of Soil Structure

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Appendix 1

Visual Evaluation of Soil Structure

Soil structure affects root penetration, water availability to plants and soil aeration. This simple, quick test assesses soil structure based on the appearance and feel of a block of soil dug out with a spade.
The scale of the test ranges from Sq1, good structure, to Sq5, poor structure.

Equipment:
Garden spade approx. 20 cm wide, 22-25 cm long.
Optional: light-coloured plastic sheet, sack or tray ~50 x 80 cm, small knife, digital camera.

When to sample:
Any time of year, but preferably when the soil is moist. If the soil is too dry or too wet it is difficult to obtain a representative sample.
Roots are best seen in an established crop or for some months after harvest.

Where to sample:
Select an area of uniform crop or soil colour or an area where you suspect there may be a problem. Within this area, plan a grid to look
at the soil at 10, preferably more, spots. On small experimental plots, it may be necessary to restrict the number to 3 or 5 per plot.

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Method of assessment:

Step	Option	Procedure
Block extraction and examination		
1. Extract soil block	Loose soil	Remove a block of soil ~15 cm thick directly to the full depth of the spade and place spade plus soil onto the sheet, tray or the ground
	Firm soil	Dig out a hole slightly wider and deeper than the spade leaving one side of the hole undisturbed. On the undisturbed side, cut down each side of the block with the spade and remove the block as above.
2. Examine soil block	Uniform structure	Remove any compacted soil or debris from around the block
	Two or more horizontal layers of differing structure	Estimate the depth of each layer and prepare to assign scores to each separately.
Block break-up		
3. Break up block (take a photograph - optional)		Measure block length and look for layers. Gently manipulate the block using both hands to reveal any cohesive layers or clumps of aggregates. If possible separate the soil into natural aggregates and man-made clods. Clods are large, hard, cohesive and rounded aggregates.
4. Break up of major aggregates to confirm score		Break larger pieces apart and fragment it until a piece of aggregate of 1.5 - 2.0 cm. Look to their shape, porosity, roots and easily of break up. Clods can be broken into non-porous aggregates with angular corners and are indicative of poor structure and higher score.
Soil scoring		
5. Assign score		Match the soil to the pictures category by category to determine which fits best.
6. Confirm score from:		Factors increasing score:
	Block extraction	Difficulty in extracting the soil block
	Aggregate shape and size	Larger, more angular, less porous, presence of large worm holes
	Roots	Clustering, thickening and deflections
	Anaerobism	Pockets or layers of grey soil, smelling of sulphur and presence of ferrous ions
	Aggregate fragmentaion	Break up larger aggregates ~ 1.5 – 2.0 cm of diameter fragments to reveal their type
7.Calculate block scores for two or more layers of differing structure		Multiply the score of each layer by its thickness and divide the product by the overall depth, e.g. for a 25 cm block with 10 cm depth of loose soil (Sq1) over a more compact (Sq3) layer at 10-25 cm depth, the block score is (1 x 10)/25 + (3 x 15)/25 = Sq 2.2

Scoring: Scores may fit between Sq categories if they have the properties of both.
Scores of 1-3 are usually acceptable whereas scores of 4 or 5 require a change of management.

16 Oct 2012

Appendix 1

Structure quality	Size and appearance of aggregates	Visible porosity and Roots	Appearance after break-up: various soils	Appearance after break-up: same soil different tillage	Distinguishing feature	Appearance and description of natural or reduced fragment of ~ 1.5 cm diameter
Sq1 **Friable** Aggregates readily crumble with fingers	Mostly < 6 mm after crumbling	Highly porous Roots throughout the soil			 Fine aggregates	 The action of breaking the block is enough to reveal them. Large aggregates are composed of smaller ones, held by roots.
Sq2 **Intact** Aggregates easy to break with one hand	A mixture of porous, rounded aggregates from 2mm - 7 cm. No clods present	Most aggregates are porous Roots throughout the soil			 High aggregate porosity	 Aggregates when obtained are rounded, very fragile, crumble very easily and are highly porous.
Sq3 **Firm** Most aggregates break with one hand	A mixture of porous aggregates from 2mm -10 cm; less than 30% are <1 cm. Some angular, non-porous aggregates (clods) may be present	Macropores and cracks present. Porosity and roots both within aggregates.			 Low aggregate porosity	 Aggregate fragments are fairly easy to obtain. They have few visible pores and are rounded. Roots usually grow through the aggregates.
Sq4 **Compact** Requires considerable effort to break aggregates with one hand	Mostly large > 10 cm and sub-angular non-porous; horizontal/platy also possible; less than 30% are <7 cm	Few macropores and cracks All roots are clustered in macropores and around aggregates			 Distinct macropores	 Aggregate fragments are easy to obtain when soil is wet, in cube shapes which are very sharp-edged and show cracks internally.
Sq5 **Very compact** Difficult to break up	Mostly large > 10 cm, very few < 7 cm, angular and non-porous	Very low porosity. Macropores may be present. May contain anaerobic zones. Few roots, if any, and restricted to cracks			 Grey-blue colour	 Aggregate fragments are easy to obtain when soil is wet, although considerable force may be needed. No pores or cracks are visible usually.

0 1 2 3 4 5 10 15 cm