

# Development of a Soil Management Information System for Horticulture



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[on behalf of the SMIS project team]

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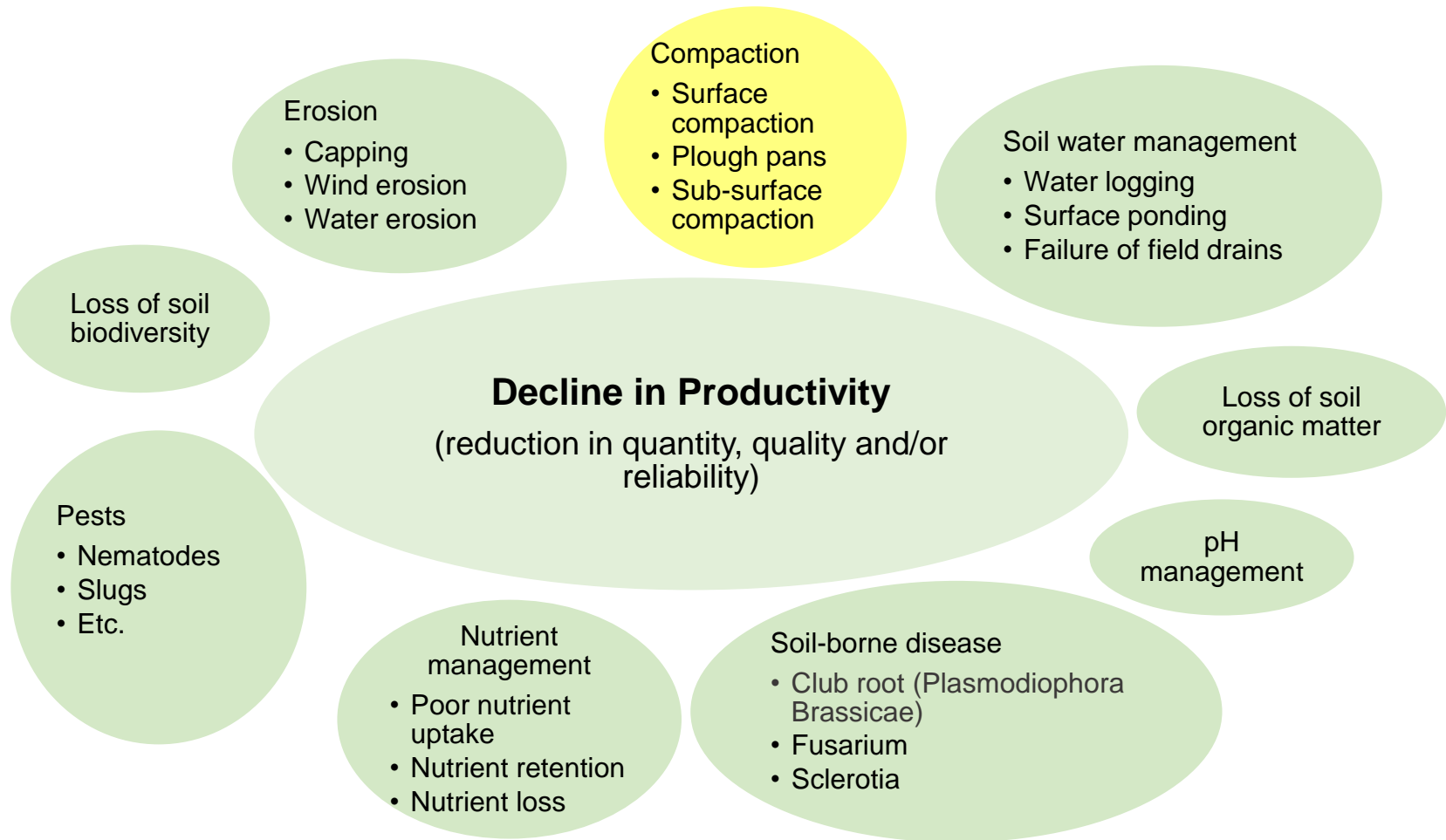
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## Outline

- Review key soil management issues
- Aims of SMIS
- Metrics of soil health: Examples of metrics that growers collect
- What useful data relating to soil management are growers collecting?
- SMIS System: Structural Overview
- Current extent of the grower data set
- SMIS: Case study examples
- Missing metrics and next steps

# Key soil management challenges: Crop specific and cross-rotational





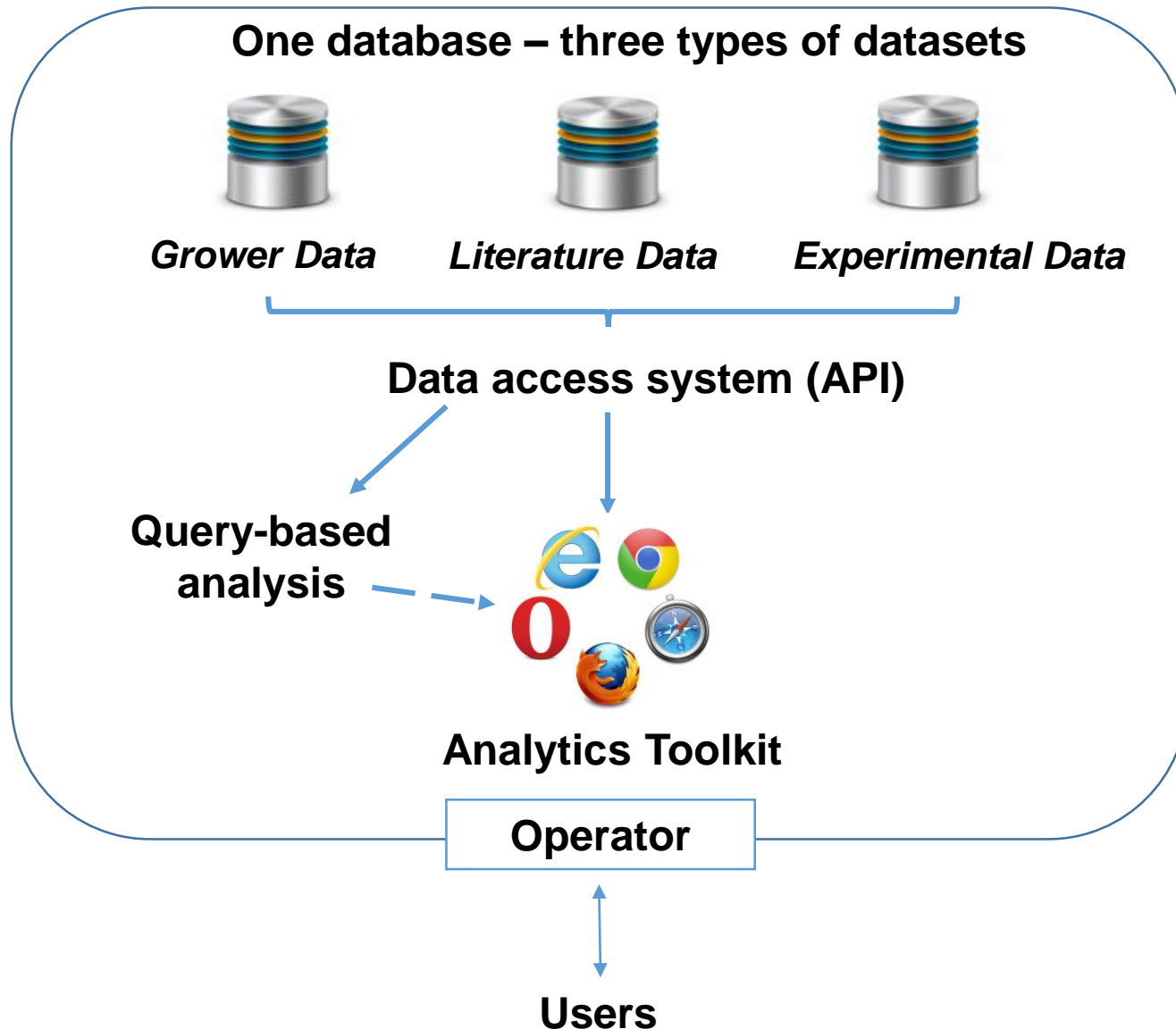
# 1. Aim of the SMIS project

Apply the principles of 'big data' to the diverse sources of soil management data, knowledge and information to provide best practice guidelines for sustainable soil management in horticulture

The SMIS can:

- **hold, represent, manipulate and manage available sources of data, knowledge and information**
  - specific effects of soil management practices on horticultural crop productivity and environmental protection
  - Seasonal and rotational context
- use **novel informatics techniques** to create and then interrogate a 'rule base' of soil management practices (and their outcomes) in different scenarios (soil type, crop, rotation, location, etc.)
- provide users with a set of **robust, empirically-based, best-practice soil management guidelines** (and the likely consequences of applying them)
- An interactive platform will be created, giving AHDB-Horticulture, and its growers, agronomists and land managers access to **guidance on contextual, effective soil management practices**

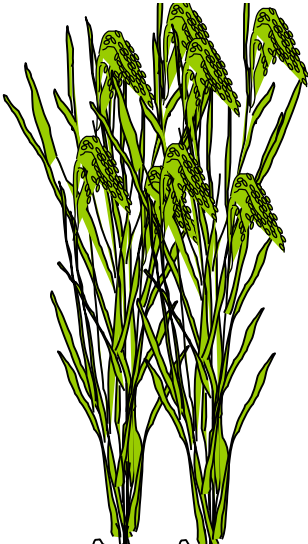
# SMIS: General system overview



# Metrics of 'soil health'

## What are growers collecting?

# Yield attributes

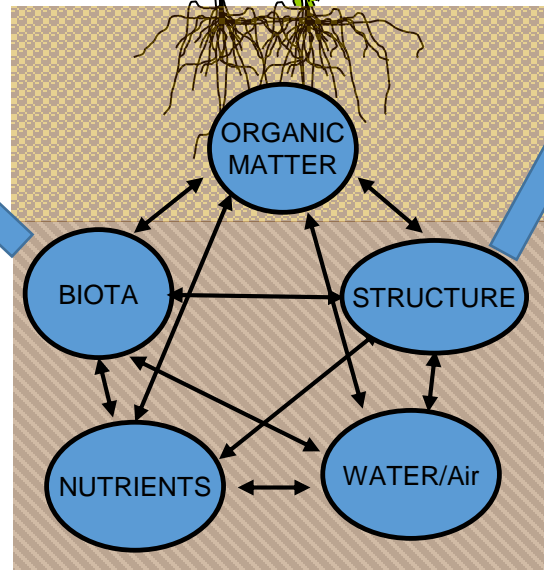


### Biological Properties

- PCN/BCN Levels
- FLN
- Foot Rot

### Physical Properties: Soil Structure

- Trafficability
- Workability/Tilth
- Drainage/water availability
- Erodibility



### 'Metrics'

- Timing, type & frequency of tillage & harvesting operations

### Nutrients

- NPK, Mg
- Trace elements (Zn, S)

"The pivotal 5"

(after Professor Karl Ritz, pers.comm)

# What useful data relating to soil management are growers collecting?

Excel interface showing a table of agricultural data. The table has columns for Heading, Crop, Heading Type, Map Sheet, NG Number, Product Name, Rate per Working Area ha, Year, Actual/Issued Date, and Field Defined Name. A filter menu is open on the left, showing various categories like Adjuvants, Application, Desiccants, etc. The data rows show various agricultural treatments and their associated details.

Heading	Crop	Heading Type	Map Sheet	NG Number	Product Name	Rate per Working Area ha	Year	Actual/Issued Date	Field Defined Name	Un
Pesticides		TF3825	8293	Activator 90	0.1	2014	31-May-14	Ellis Taylor.West/02	L	
Pesticides		TF3925	2792	Activator 90	0.099	2014	31-May-14	Rowers.A	L	
Pesticides		TF3928	7583	Activator 90	0.1	2014	31-May-14	F54.A/02	L	
Pesticides		TF4026	4605	Activator 90	0.1	2014	31-May-14	Ellis Bank	L	
Pesticides		TF4028	1910	Activator 90	0.1	2014	31-May-14	F29/30	L	
Pesticides		TF4029	9611	Activator 90	0.1	2014	31-May-14	F39	L	
Pesticides		TF3928	0176	Podium	0.9	2015	07-Aug-15	F62.A	L	
Pesticides		TF4027	5676	Assist	0.5	2014	01-Aug-14	F20.A	L	
Pesticides		TF4027	5676	Podstick	1	2014	01-Aug-14	F20.A	L	
Pesticides		TF4029	3940	Podium	0.9	2015	07-Aug-15	F45/50.A	L	
Pesticides		TF4129	0335	Assist	0.5	2014	01-Aug-14	F38.A/04	L	
Pesticides		TF4129	0335	Podstick	1	2014	01-Aug-14	F38.A/04	L	
Pesticides		TF4129	1062	Assist	0.5	2014	01-Aug-14	F37	L	
Pesticides		TF4129	1062	Podstick	1	2014	01-Aug-14	F37	L	
ncro Pesticides		TF 3731	0378	Activator 90	0.2	2014	03-Jun-14	Hcct 7/11	L	
ncro Pesticides		TF3631	5554	Activator 90	0.186	2015	03-Jun-15	Hcct 5/9	L	
ncro Pesticides		TF3631	8154	Activator 90	0.2	2014	03-Jun-14	Hcct 6/10	L	
ncro Pesticides		TF3632	5724	Activator 90	0.1	2011	20-Apr-11	Hcct 1/1a.Marfona/04	L	
ncro Pesticides		TF3632	5724	Activator 90	0.1	2011	20-Apr-11	Hcct 1/1a.Maris Piper/03	L	
ncro Pesticides		TF3632	5724	Ranman Twinpack	0.15	2011	29-Jun-11	Hcct 1/1a.Marfona/04	Ha	
ncro Pesticides		TF3632	5724	Ranman Twinpack	0.15	2011	29-Jun-11	Hcct 1/1a.Maris Piper/03	Ha	
ncro Pesticides		TF3632	9628	Activator 90	0.1	2011	20-Apr-11	Hcct 2/3a	L	
ncro Pesticides		TF3632	9628	Ranman Twinpack	0.147	2011	29-Jun-11	Hcct 2/3a	Ha	
ncro Pesticides		TF3825	8293	Ranman Twinpack	0.147	2011	29-Jun-11	Ellis Taylor.West/02	Ha	
ncro Pesticides		TF3830	5828	Ranman Twinpack	0.15	2010	30-Jun-10	Hcct 54/5/6.Marfona	Ha	
Adjuvants	Potatoes Maincro	Pesticides	TF3830	5828	Ranman Twinpack	0.15	2010	30-Jun-10	Hcct 54/5/6.Maris Piper/02	Ha
Adjuvants	Potatoes Maincro	Pesticides	TF3830	5828	Ranman Twinpack	0.15	2010	30-Jun-10	Hcct 54/5/6.Melody/03	Ha
Adjuvants	Potatoes Maincro	Pesticides	TF3830	5828	Ranman Twinpack	0.15	2010	07-Jul-10	Hcct 54/5/6.Marfona	Ha
Adjuvants	Potatoes Maincro	Pesticides	TF3830	5828	Ranman Twinpack	0.15	2010	07-Jul-10	Hcct 54/5/6.Maris Piper/02	Ha
Adjuvants	Potatoes Maincro	Pesticides	TF3830	5828	Ranman Twinpack	0.15	2010	07-Jul-10	Hcct 54/5/6.Melody/03	Ha
Adjuvants	Potatoes Maincro	Pesticides	TF3928	0176	Ranman Twinpack	0.147	2011	29-Jun-11	F62.A	Ha
Adjuvants	Potatoes Maincro	Pesticides	TF3928	6634	Activator 90	0.2	2013	18-Jun-13	F67.A	L
Adjuvants	Potatoes Maincro	Pesticides	TF3928	7583	Activator 90	0.2	2013	18-Jun-13	F54.A	L
Adjuvants	Potatoes Maincro	Pesticides	TF3929	3050	Phase 11	0.985	2015	10-Jun-15	F60	L
Adjuvants	Potatoes Maincro	Pesticides	TF3929	9517	Ranman Twinpack	0.147	2011	29-Jun-11	F56	Ha
Adjuvants	Potatoes Maincro	Pesticides	TF3930	0634	Ranman Twinpack	0.15	2010	30-Jun-10	Hcct 51/2/3	Ha
Adjuvants	Potatoes Maincro	Pesticides	TF3930	0634	Ranman Twinpack	0.15	2010	08-Jul-10	Hcct 51/2/3	Ha
Adjuvants	Potatoes Maincro	Pesticides	TF4025	4811	Ranman Twinpack	0.147	2011	29-Jun-11	F72/5.Marfona/04	Ha
Adjuvants	Potatoes Maincro	Pesticides	TF4025	4811	Ranman Twinpack	0.147	2011	29-Jun-11	F72/5.Whole/03.DO NOT BLIGHT SPRAY TRIAL AREA	Ha
Adjuvants	Potatoes Maincro	Pesticides	TF4026	7585	Activator 90	0.2	2011	01-Jun-11	F9.Cassablanca/04	L
Adjuvants	Potatoes Maincro	Pesticides	TF4026	7585	Activator 90	0.2	2011	01-Jun-11	F9.Marfona/05	L
Adjuvants	Potatoes Maincro	Pesticides	TF4026	7585	Activator 90	0.2	2011	01-Jun-11	F9.Nectar/03	L

# Tillage operations during establishment

Microsoft Excel interface showing a spreadsheet with columns: Heading, Crop, Heading Type, Map Sheet, NG Number, Product Name, Year, Actual/Issued Date, Field Defined Name, Units, Working Area, Official Area, OS Area. A filter menu is open over the Product Name column, showing a list of operations like '3 Leg Buster', 'AHW Combi Drill(4m)', etc.

	A	B	C	D	E	F	H	I	J	K	L	M	N	O
	Heading	Crop	Heading Type	Map Sheet	NG Number	Product Name	Year	Actual/Issued Date	Field Defined Name	Units	Working Area h	Official Area h	OS Area	
8198	Establishment	Calabrese	Machinery Costs	TF3925	4633		2011	23-Jul-10	Ellis Halgarth	ha	2.91	2.91	3.17	
8199	Establishment	Calabrese	Machinery Costs	TF3925	4633		2011	23-Sep-10	Ellis Halgarth	ha	2.91	2.91	3.17	
8200	Establishment	Calabrese	Machinery Costs	TF3925	4633		2011	09-Sep-10	Ellis Halgarth	ha	2.91	2.91	3.17	
8201	Establishment	Calabrese	Machinery Costs	TF4025	4811		2011	24-Sep-10	F77 A	ha	9.65	9.65	0	
8202	Establishment	Calabrese	Machinery Costs	TF4025	4811		2011	24-Sep-10	F77 A	ha	9.65	9.65	0	
8203	Establishment	Calabrese	Machinery Costs	TF4026	1793		2011	21-Jan-11	F8a A	ha	7.22	7.22	11.79	
8204	Establishment	Calabrese	Machinery Costs	TF4026	4605		2011	19-Jan-11	Ellis Bank	ha	4.81	4.81	4.83	
8205	Establishment	Calabrese	Machinery Costs	TF4027	5823		2011	20-Jan-11	F13 A	ha	14.01	14.01	14.65	
8206	Establishment	Calabrese	Machinery Costs	TF4027	8129		2011	11-Nov-10	F12 A	ha	11.82	11.82	13.35	
8207	Establishment	Calabrese	Machinery Costs	TF4228	8295		2011	24-Sep-10	Jep 66	ha	6.95	6.95	7.13	
8208	Establishment	Calabrese	Machinery Costs	TF4228	8295		2011	15-Nov-10	Jep 66	ha	6.95	6.95	7.13	
8209	Establishment	Calabrese	Machinery Costs	TF4427	2697		2011	15-Oct-10	Jep 59	ha	12.37	12.37	12.96	
8210	Establishment	Calabrese	Machinery Costs	TF4530	8063		2011	25-Jan-11	Jep 40	ha	16.27	16.39	16.84	
8211	Establishment	Cauliflowers	Machinery Costs	TF 3925	9862		2010	05-Nov-09	Ellis-Chapmans	ha	2.99	2.99	3.16	
8212	Establishment	Cauliflowers	Machinery Costs	TF3531	8257		2012	06-Sep-11	Hcct Johnsons	ha	13.05	13.05	13.42	
8213	Establishment	Cauliflowers	Machinery Costs	TF3631	8154		2012	06-Sep-11	Hcct 6/10	ha	13.36	13.36	14.32	
8214	Establishment	Cauliflowers	Machinery Costs	TF3826	3806		2011	15-Feb-11	Ellis Muntons	ha	11.33	11.33	11.26	
8215	Establishment	Cauliflowers	Machinery Costs	TF3925	4283		2010	04-Nov-09	Yard Field	ha	3.36	3.36	3.56	
8216	Establishment	Cauliflowers	Machinery Costs	TF3925	4633		2010	03-Nov-09	Ellis Halgarth	ha	2.91	2.91	3.17	
8217	Establishment	Cauliflowers	Machinery Costs	TF3925	4825		2011	23-Jul-10	Ellis A17	ha	2.22	2.22	2.51	
8218	Establishment	Cauliflowers	Machinery Costs	TF3925	4825		2010	26-Oct-09	Ellis A17	ha	2.22	2.22	2.51	
8219	Establishment	Cauliflowers	Machinery Costs	TF3925	4825		2011	23-Sep-10	Ellis A17	ha	2.22	2.22	2.51	
8220	Establishment	Cauliflowers	Machinery Costs	TF3925	4825		2011	09-Sep-10	Ellis A17	ha	2.22	2.22	2.51	
8221	Establishment	Cauliflowers	Machinery Costs	TF3925	8779		2010	23-Oct-09	F12	ha	11.95	11.95	13.05	
8222	Establishment	Cauliflowers	Machinery Costs	TF3928	0176		2010	08-Dec-09	F63 A	ha	38.73	38.73	58.2	
8223	Establishment	Cauliflowers	Machinery Costs	TF3928	6634	Plough	2010	20-Nov-09	F67	ha	5.08	5.08	5.49	
8224	Establishment	Cauliflowers	Machinery Costs	TF3928	7583	Plough	2011	11-Oct-10	F54 A	ha	10	10	11.17	
8225	Establishment	Cauliflowers	Machinery Costs	TF3928	7583	Plough	2015	11-Oct-14	F54 A/02	ha	10	10	11.17	
8226	Establishment	Cauliflowers	Machinery Costs	TF3929	2107	Plough	2010	24-Nov-09	F61 A	ha	9.15	9.15	11.47	
8227	Establishment	Cauliflowers	Machinery Costs	TF3929	5201	Plough	2011	11-Oct-10	F59 A	ha	12.21	12.21	13.5	
8228	Establishment	Cauliflowers	Machinery Costs	TF4025	4245	Plough	2010	13-Nov-09	F71	ha	10.41	10.41	10.87	
8229	Establishment	Cauliflowers	Machinery Costs	TF4025	4287	Plough	2010	06-Nov-09	Ellis House	ha	5.98	5.98	6.64	
8230	Establishment	Cauliflowers	Machinery Costs	TF4025	7174	Plough	2014	28-Nov-13	F68/9.ELU/04	ha	8.82	8.82	10.29	
8231	Establishment	Cauliflowers	Machinery Costs	TF4026	0350	Plough	2010	04-Dec-09	F5	ha	3.94	3.94	4.24	
8232	Establishment	Cauliflowers	Machinery Costs	TF4026	2342	Plough	2010	19-Feb-10	F7	ha	12.84	12.84	14	
8233	Establishment	Cauliflowers	Machinery Costs	TF4026	7585	Flail Topping	2014	25-Feb-14	F9/02	ha	23.56	23.56	23.56	
8234	Establishment	Cauliflowers	Machinery Costs	TF4026	7585	Plough	2014	20-Feb-14	F9/02	ha	23.56	23.56	23.56	
8235	Establishment	Cauliflowers	Machinery Costs	TF4026	7585	Plough	2014	25-Feb-14	F9/02	ha	23.56	23.56	23.56	
8236	Establishment	Cauliflowers	Machinery Costs	TF4027	8182	Plough	2010	09-Dec-09	F21	ha	10.1	10.1	11.02	
8237	Establishment	Cauliflowers	Machinery Costs	TF4028	3385	Plough	2011	04-Nov-10	F43/4 A	ha	20.64	20.64	22.04	
8238	Establishment	Cauliflowers	Machinery Costs	TF4028	6463	Plough	2011	12-Nov-10	F41a	ha	8.44	8.44	15.16	
8239	Establishment	Cauliflowers	Machinery Costs	TF4029	1101	Flatliffing	2013	20-Feb-13	F52	ha	17.84	17.84	18.44	

Source: Grower G dataset



# Cross rotational tillage operations for a specific field

	A	B	C	D	E	F	H	I	J	K	L	M	N	O
1	Heading	Crop	Heading Type	Map Shee	NG Numbe	Product Name	Yea	Actual/Issued Date	Field Defined Nam	Units	Working Area	Official Area	OS Are	
8250	Establishment	Cauliflowers	Machinery Costs	TF4328	9868	Plough	2014	23-Jan-14	Jep 23	ha	13.62	13.62	0	
8906	Establishment	Peas Vining	Machinery Costs	TF4328	9868	Plough	2010	18-Nov-09	Jep 23	ha	13.18	13.18	0	
8907	Establishment	Peas Vining	Machinery Costs	TF4328	9868	Roll	2010	21-May-10	Jep 23	ha	13.18	13.18	0	
8908	Establishment	Peas Vining	Machinery Costs	TF4328	9868	Simba Culti Press	2010	21-Apr-10	Jep 23	ha	13.18	13.18	0	
8909	Establishment	Peas Vining	Machinery Costs	TF4328	9868	WFL Pea Drill+Cult	2010	21-May-10	Jep 23	ha	13.18	13.18	0	
9702	Establishment	Potatoes Maincro	Machinery Costs	TF4328	9868	Disc & Press	2011	11-Aug-10	Jep 23	ha	13.62	13.62	0	
9703	Establishment	Potatoes Maincro	Machinery Costs	TF4328	9868	Flatlifting	2011	11-Aug-10	Jep 23	ha	13.62	13.62	0	
9704	Establishment	Potatoes Maincro	Machinery Costs	TF4328	9868	Plough	2011	04-Nov-10	Jep 23	ha	13.62	13.62	0	
9705	Establishment	Potatoes Maincro	Machinery Costs	TF4328	9868	Potato Cultivator GForce 6m	2011	02-Apr-11	Jep 23	ha	13.62	13.62	0	
9706	Establishment	Potatoes Maincro	Machinery Costs	TF4328	9868	Potato Planter AVR 4 Row	2011	02-Apr-11	Jep 23	ha	13.62	13.62	0	
9707	Establishment	Potatoes Maincro	Machinery Costs	TF4328	9868	WFL Fert Application	2011	21-Sep-10	Jep 23	ha	13.62	13.62	0	
10191	Establishment	Sugar Beet	Machinery Costs	TF4328	9868	Flatlifting	2013	27-Aug-12	Jep 23	ha	13.62	13.62	0	
10192	Establishment	Sugar Beet	Machinery Costs	TF4328	9868	LFP Beet Drill	2013	05-Apr-13	Jep 23	ha	13.62	13.62	0	
10193	Establishment	Sugar Beet	Machinery Costs	TF4328	9868	Plough	2013	29-Oct-12	Jep 23	ha	13.62	13.62	0	
10194	Establishment	Sugar Beet	Machinery Costs	TF4328	9868	Preperator	2013	05-Apr-13	Jep 23	ha	13.62	13.62	0	
10931	Establishment	Wheat Winter	Machinery Costs	TF4328	9868	Top Down	2012	21-Sep-11	Jep 23	ha	13.62	13.62	0	
10932	Establishment	Wheat Winter	Machinery Costs	TF4328	9868	Vardestadt Drill 6m	2012	21-Sep-11	Jep 23	ha	13.62	13.62	0	
19349	Harvest	Peas Vining	Machinery Costs	TF4328	9868	Pea Vining	2010	26-Jul-10	Jep 23	ha	13.18	13.18	0	
19471	Harvest	Potatoes Maincro	Machinery Costs	TF4328	9868	WFL Potato Harvesting	2011	16-Sep-11	Jep 23	ha	13.62	13.62	0	
19576	Harvest	Sugar Beet	Machinery Costs	TF4328	9868	LFP Beet Harvest	2013	23-Jan-14	Jep 23	ha	13.62	13.62	0	
19795	Harvest	Wheat Winter	Machinery Costs	TF4328	9868	WFL Combine	2012	23-Aug-12	Jep 23	ha	13.62	13.62	0	

- Grower data can provide information on the type, timing and frequency and intensity of tillage operations on a crop specific and rotational context.
- Grower data can also provide useful information on a wide range of soil management practices
  - effect of bio-fumigants (and other Brassica crops) on PCN/BCN in a rotational context.
  - influence of organic amendments on soils.....tillage operations/yield/fertiliser use
  - influence of cover crops on soils.....tillage operations/yield/fertiliser use
  - effect of late harvested crops (sugar beet, maize) on subsequent crop yields....

## Specific tillage operations can be further classified and incorporated into machine learning queries

Product_Name	Technical Description	Tillage classification
WFL Digestate Application	/	/
Tramsread Digestate Application	/	/
3 Leg Buster	Sub soiler	Deep Tillage
Bust Tramlines	Sub soiler	Deep Tillage
Flatlifting	Sub soiler	Deep Tillage
Sumo Trio	Sub soiler w discs and roller	Progressive tillage (Shallow to Deep)
Sumo Trio + Seeding	Sub soiler w discs and roller + drill	Progressive tillage (Shallow to Deep) + Drill
AHW Combi Drill (4m)	Power harrow + seed drill	Rotational Tillage
Combination Drill	Power harrow + seed drill	Rotational Tillage
Disc & Press	Discs and roller	Shallow Tillage
Sneath Beet Drill + Cultivate [18 row Monocem drill, Lemkin Terratilt cultivator + challenger 55 crawler]	/	Shallow Tillage
LFP Beet Drill	Beet Drill	Shallow Tillage
Maize Drilling	Maize Drill	Shallow Tillage
Plough	Mouldboard plough	Inversion tillage
Potato Cultivator GForce 6m	Power harrow bed former	Rotational Tillage
Potato Planter AVR 4 Row	Potato Planter	/
Interrow Cultivate Potatoes	Shallow tines and bed-forming	Shallow Tillage
Power Harrow	Power Harrow	Rotational Tillage
Preperator	Shallow tines	Shallow Tillage
Roll	Cambridge roller	/
Rotovating	Power harrow	Rotational Tillage
Simba Culti Press	Tines and packer roll	Shallow Tillage
Top Down	discs/tines/levelling and packer	Shallow Tillage
Vardestadt Drill 6m	Likely to have shallow tillage	Shallow Tillage

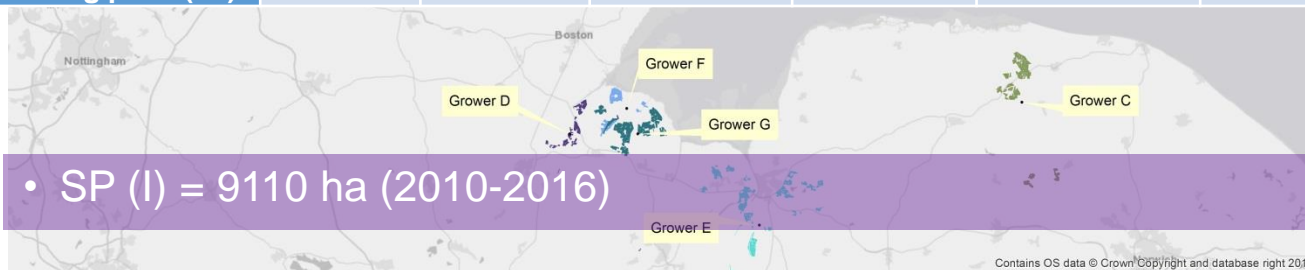
Source: Grower G dataset

# Temporal & spatial extent of the grower data set



Vining pea area = 3890 ha within >60,000 ha

Grower	Year							
	2008	2009	2010	2011	2012	2013	2014	2015
AY-LM (A)	/	/	/	850 (0)	747 (0)	1246 (0)	825 (0)	1097 (35)
AY-R (B)	/	/	/	966 (0)	699 (0)	1509 (0)	753 (0)	967 (0)
AN (C)	/	/	/	1074 (122)	1138 (108)	890 (92)	1157 (180)	970 (175)
JBF (D)	434 (28)	480 (45)	520 (43)	482 (38)	494 (44)	690 (44)	486 (38)	340 (41)
CF (E)	785 (0)	986 (0)	1379 (36)	1516 (40)	1521 (0)	1875 (0)	2403 (0)	2607 (67)
HF (F)	/	/	666 (100)	886 (0)	728 (58)	1027 (168)	1037 (105)	1216 (120)
WF (G)	/	/	1752 (304)	1638 (256)	1875 (238)	1965 (238)	2144 (255)	1572 (140)
JSR (H)	/	/	/	/	2159 (0)	3068 (240)	3386 (300)	3563 (265)
<b>Total area (ha)</b>	<b>1219</b>	<b>1466</b>	<b>4317</b>	<b>7412</b>	<b>9961</b>	<b>12270</b>	<b>12191</b>	<b>11663</b>
<b>Vining peas (ha)</b>	<b>28</b>	<b>45</b>	<b>483</b>	<b>456</b>	<b>448</b>	<b>782</b>	<b>878</b>	<b>843</b>



• SP (I) = 9110 ha (2010-2016)

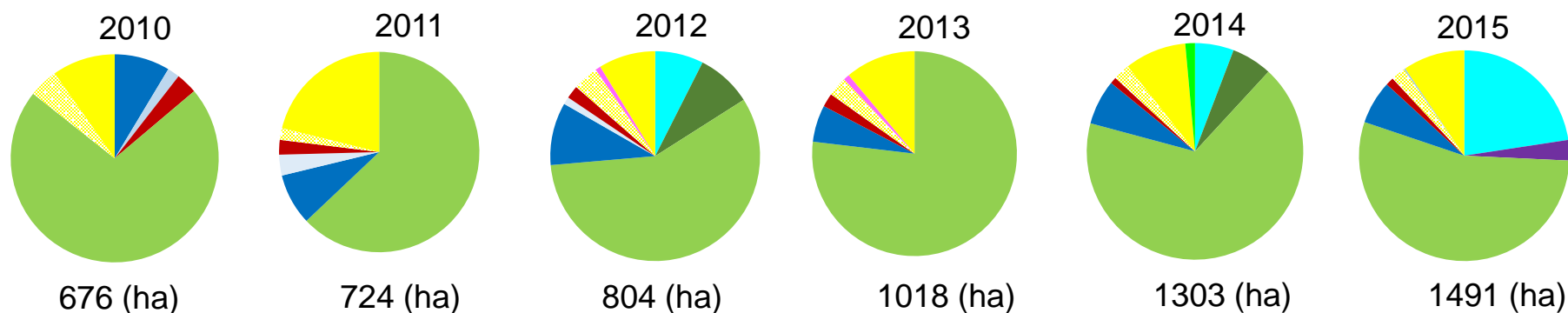
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Grower data

## Field vegetables included within grower datasets

Crop	2010	2011	2012	2013	2014	2015	Crop specific total (ha)
Celeriac	58	60	78	59	87	99	441
Chicory	13	24	9	/	/	/	46
Fennel	22	17	16	22	13	19	109
Onions <sub>(Set)</sub>	31	14	32	31	33	33	174
Onions <sub>(Drilled)</sub>	66	153	71	113	120	141	664
Daffodils	/	/	6.6	10	/	/	16.6
Beans Dried Spring	/	/	60	126	76	337	599
Beans French	/	/	69	/	79	/	148
Salads	/	/	/	/	19	/	19
<b>Total annual area (ha)</b>	<b>189</b>	<b>268</b>	<b>340</b>	<b>361</b>	<b>426</b>	<b>633</b>	<b>2,220</b>



- Total 6-year cultivated area of horticultural crops = 6,016 (ha)



# Grower specific crop diversity and rotational contexts cont....

Grower C  
970 (ha)

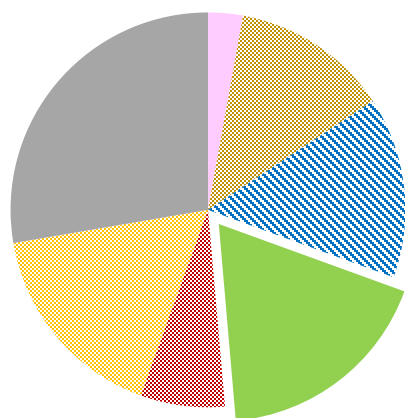
Soil Textural Class	% of cropped area
SL	94%
CL	6%

Grower D  
327 (ha)

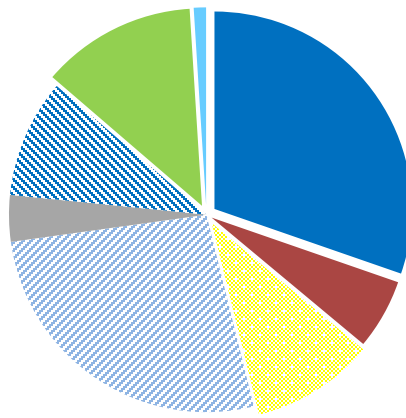
Soil Textural Class	% of cropped area
ZCL	99%
ZC	1%

Grower E  
2607 (ha)

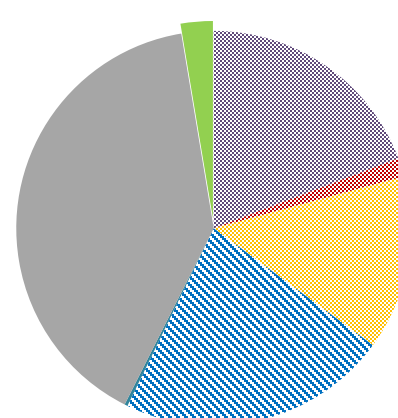
Soil Textural Class	% of cropped area
CL	34%
ZCL	23%
SL	23%



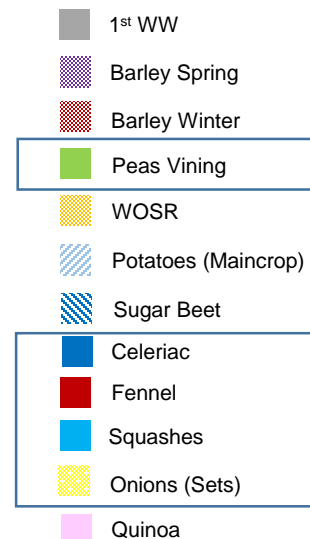
Horticultural Crops  
(175 ha)



Horticultural Crops  
(196 ha)



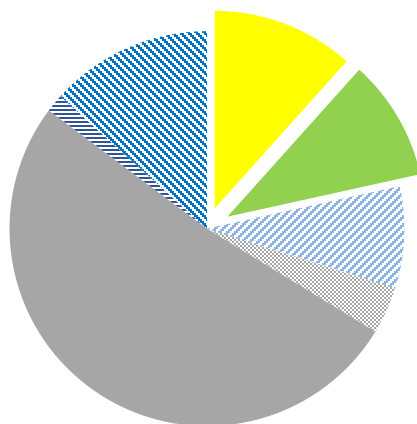
Horticultural Crops  
(68 ha)



# Grower specific crop diversity and rotational contexts cont...

Grower F  
1215 (ha)

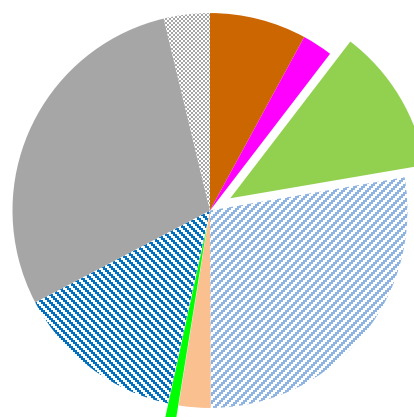
Soil Textural Class	% of cropped area
ZCL	72%
ZC	28%



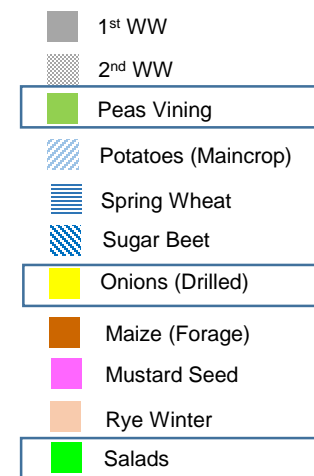
Horticultural Crops  
(261 ha)

Grower G  
2144 (ha)

Soil Textural Class	% of cropped area
ZCL	95%
C	5%

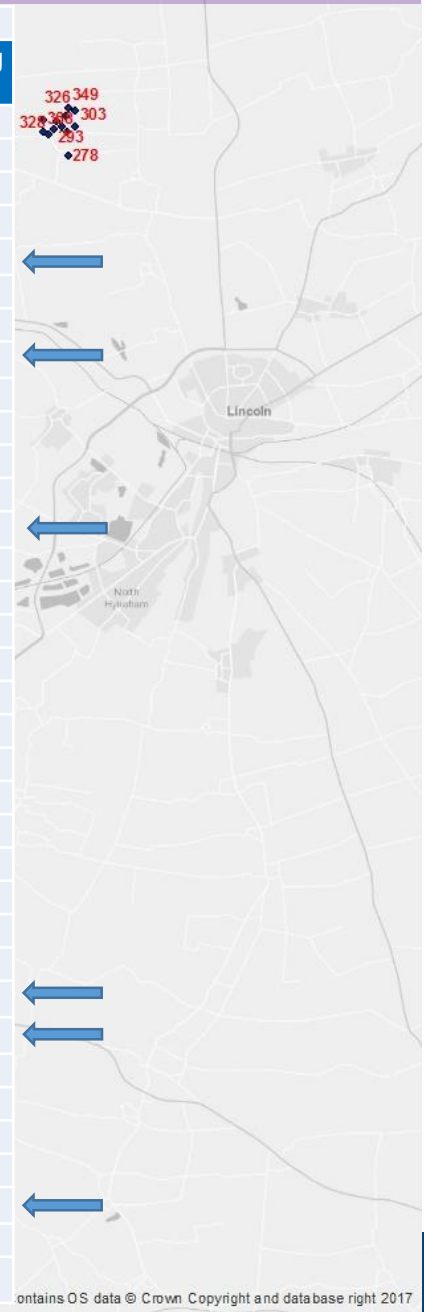


Horticultural Crops  
(274 ha)





Crop	Working Area (ha)							Total Working Area (ha)
	2010	2011	2012	2013	2014	2015	2016	
Barley Spring	28.1	13.3						41.4
Beetroot						1.2	9.0	10.1
Broccoli						15.4	20.1	35.5
Cabbage Head	4.0	19.5						23.5
Carrots	106.8	85.4	66.1	64.5	64.0	70.6	75.1	533
Collards	41.0	40.3						81.2
Green Cover Crop						15.8	38.3	54.1
Leeks	133.7	109.3	79.9	82.1	71.6	64.5	60.4	601
Maize Forage		18.5	19.2	42.0	16.7	44.8	70.4	212
Mustard Seed	23.1	15.6			2.4			41.1
Organic Carrots		10.0	8.6					18.6
Organic Parsnips			3.1	4.0	5.2			12.3
Parsnips	67.2	72.7	58.7	81.1	97.0	80.3	88.4	545
Peas Vining		25.0						25.0
Point Cabbage						8.8	10.0	18.8
Potatoes Earlies	7.8	9.3						17.1
Potatoes Maincrop	122.6	125.4	143.9	150.6	152.1	128.7	103.6	927
Pumpkins						14.3	16.0	30.3
Rented Barley Winter	16.4	10.0						26.4
Rented out Maize			35.4	14.4	84.7	31.0	102.5	268
Rented out Pigs							24.7	24.7
Rented out Vining Peas	45.2		36.9	36.6	23.3	35.8	11.4	189
Rhubarb	26.0	24.2	23.2	27.3	33.2	40.2	39.9	214
Savoy Cabbage	47.6	38.1						85.7
Savoy/Green			7.5	8.0	6.3	5.8	12.9	40.5
Spring Barley	77.7	89.6	107.8	115.0	62.6	85.2	21.2	559
Spring Beans					92.5	64.3	37.7	194
Spring Green	9.6		22.9	23.1	24.5	23.1	26.0	129
Sugar Beet	109.8	108.7	111.8	131.6	113.0	49.1		624
White Cabbage	46.4	45.1	53.7					145
Winter Greens		13.7		15.8	16.8	21.5	10.9	78.6
Winter OSR	126.4	166.0	126.4	78.8	82.2	85.6	97.1	762
Winter Savoy / Green Cab			43.2	24.4	27.8	40.5	22.5	158
Winter Wheat	271.6	300.7	300.2	370.6	367.7	388.5	383.7	2383
<b>Grand Total</b>	<b>1311</b>	<b>1340</b>	<b>1248</b>	<b>1270</b>	<b>1344</b>	<b>1315</b>	<b>1282</b>	<b>9110</b>



# Summary of total number of field operations undertaken during crop establishment of Parsnips across the SP (I) landbank

<b>Parsnips</b>	<b>2010</b>	<b>2011</b>	<b>2012</b>	<b>2013</b>	<b>2014</b>	<b>2015</b>	<b>2016</b>	<b>Total</b>
2 Bed Ridger		5						5
3 Bed Ridger	2	1	1	10	12	8	8	42
Bed Former	2	1	9	15	16	16	15	74
Bedform	16	12						28
CARROT/SNIP Drilling		1		9	20	15	10	55
Dam Dyke Installation			4		1		2	7
Dam Dyke Removal			1					1
Destone	13	5	2					20
De-Stoning	2	1	2	5	12	7	8	37
Disc		1		3	2	1	3	10
Disc and Mow							3	3
Drill - Precision	4	12	10	7			5	38
Dutch Harrow	2	1				13	15	31
Fertiliser App	10	5	9	10	13	8	14	69
Lay / Remove Cabbage Netting						1		1
Lilleston Wheeling					12		1	13
Plough	18	10	9	14	17	9	15	92
Plough Press					1			1
Ridge 3 Bed			4					4
Roll						2		2
Rotavate		5	1	1	3	4	5	19
Spread Straw		2		1	2	1		6
Spread Straw +Poly		1		1	2	1	1	6
Steerage Hoe			9		1			10
Subsoil	2	12	10	15	18	17	16	90
Sumo		1		1				2
Superflow		2				7	9	18
Superflow Drag			1	1	5	6		13
Top and Rotavate							1	1
Topping		3			1	2	2	8
Vaderstad Carrier 925 Demo						1		1
Vaderstad Carrier L 625						3		3
Vaderstad RDA400S(Drill)						2		2
<b>Total</b>	<b>75</b>	<b>88</b>	<b>73</b>	<b>93</b>	<b>143</b>	<b>127</b>	<b>135</b>	<b>734</b>





# LandIS derived Workability Days for Grower G

- Timing of tillage/harvesting operations can be linked to 'Workability Days' in order to identify those operations undertaken at 'Field Capacity' and thus likely to cause compaction.

Grower F: Workability Days, Workability Codes and Wetness Classes.

SITE	Soil Series	Name of Soil Series	Dry Year				Median Year				Wet Year			
			FROM	TO	WA_CODE	Wetness Class	FROM	TO	WA_CODE	Wetness Class	FROM	TO	WA_CODE	Wetness Class
TF56000200	4	ADVENTURERS'	31-Jan	20-Mar	a	I	09-Jan	04-Apr	a	I	18-Dec	25-Apr	a	I
TF56000200	5	AGNEY	31-Jan	20-Mar	a	II	09-Jan	04-Apr	a	II	08-Nov	25-Apr	c	II
TF56000200	112	BECCELES	22-Dec	05-Mar	c	III	30-Nov	20-Mar	c	III	08-Nov	10-Apr	c	III
TF56000200	124	BLACKWOOD	10-Feb	30-Mar	aa	I	19-Jan	14-Apr	aa	I	28-Dec	05-May	aa	I
TF56000200	170	BURLINGHAM	11-Jan	10-Mar	b	II	20-Dec	25-Mar	b	II	28-Nov	15-Apr	b	II
TF56000200	173	BARROW	31-Jan	20-Mar	a	I	09-Jan	04-Apr	a	I	18-Dec	25-Apr	a	I
TF56000200	175	BLACKTOFT	31-Jan	20-Mar	a	I	09-Jan	04-Apr	a	I	18-Dec	25-Apr	a	I
TF56000200	313	DOWELS	11-Jan	10-Mar	b	III	20-Dec	25-Mar	b	III	08-Nov	15-Apr	c	III
TF56000200	314	DOWNHOLLAND	31-Jan	20-Mar	a	I	09-Jan	04-Apr	a	I	18-Dec	25-Apr	a	I
TF56000200	351	DOWNHAM	10-Feb	30-Mar	aa	I	19-Jan	14-Apr	aa	I	28-Dec	05-May	aa	I
TF56000200	419	EVESHAM	01-Jan	07-Mar	bc	II	10-Dec	22-Mar	bc	II	08-Nov	12-Apr	c	II
TF56000200	428	EBSTREE	10-Feb	30-Mar	aa	I	19-Jan	14-Apr	aa	I	28-Dec	05-May	aa	I
TF56000200	442	EASTVILLE	31-Jan	20-Mar	a	I	09-Jan	04-Apr	a	I	18-Dec	25-Apr	a	I
TF56000200	500	FAIRFIELD	11-Jan	10-Mar	b	II	20-Dec	25-Mar	b	II	08-Nov	15-Apr	c	II

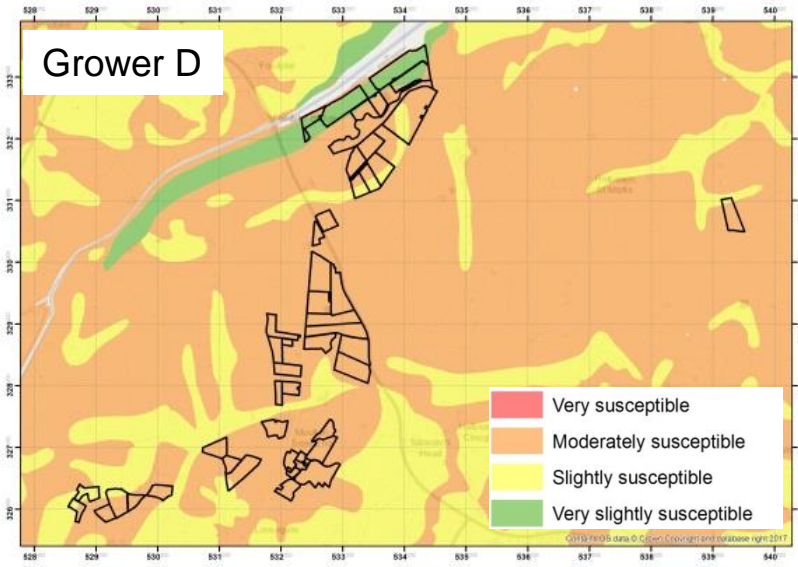
Adjusted based on whether for the years 2010-2015 the autumn and spring periods were associated with rainfall considered to fall within the Dry (<25<sup>th</sup> Percentile), Median (25<sup>th</sup> -75<sup>th</sup> Percentile) or Wet Quartile (75<sup>th</sup> Percentile) relative to the 1940-1970 average.

- Machine learning approaches can be used to quantify the impacts of these tillage/harvesting operations on yield in a rotational context.

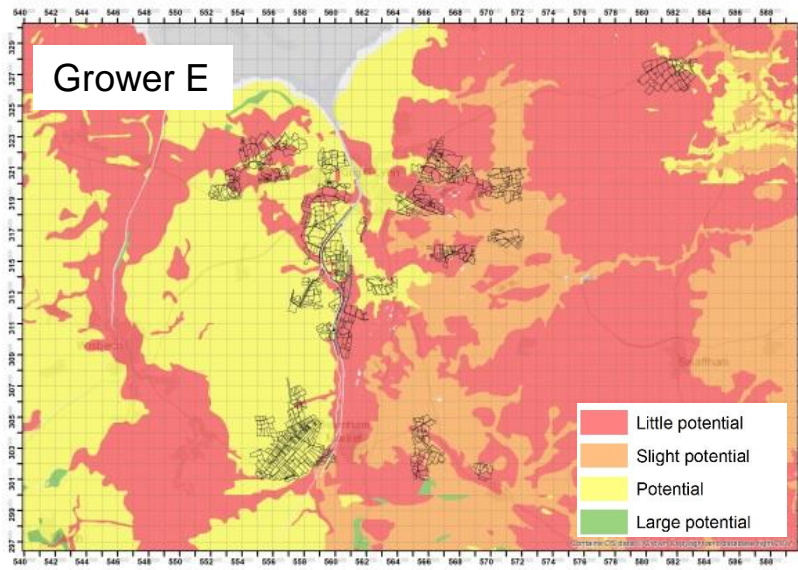
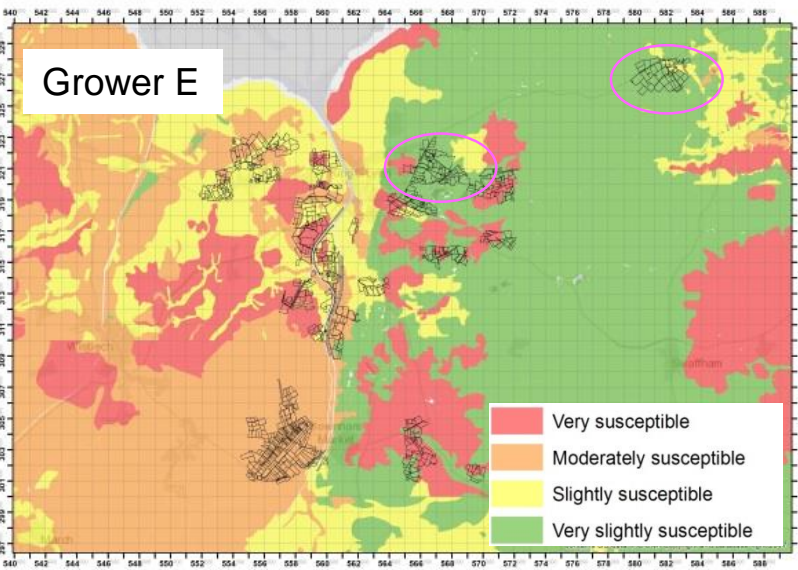
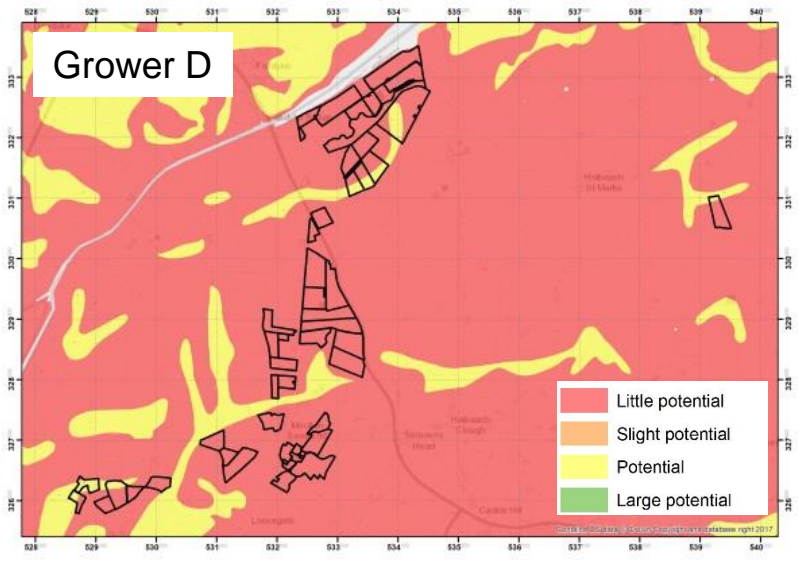
## Grower G: Tillage operations undertaken outside of 'Workability Days'.

Crop	Machinery Operation Recorded	No. of times operation recorded	No. of times operation occurred outside MWD	% of operations undertaken outside Workability Days
Cauliflowers	3 Leg Buster	2	2	100%
	Disc and Press	1	0	0.0%
	Flatlifting	3	1	33.3%
	Plough	37	7	18.9%
	Sumo Trio	3	0	0%
	Top Down	3	2	66.7%
	Spray Operation	51	5	9.8%
Vining Peas	3 Leg Buster	1	0	0%
	Bust Tramlines	1	0	0%
	Disc & Press	17	0	0%
	Fill in Furrows	3	0	0%
	Flatlifting	29	0	0%
	Pea Vining (Harvest)	65	0	0%
	Plough	93	3	3.2%
	Preperator	47	0	0%
	Sumo Trio	22	1	4.5%
	Top Down	5	2	40.0%
	Vardestadt Drill 6m	85	0	0%
	WFL Pea Drill+Cult	16	0	0%
	WFL Spray	511	4	0.8%

# Susceptibility to compaction

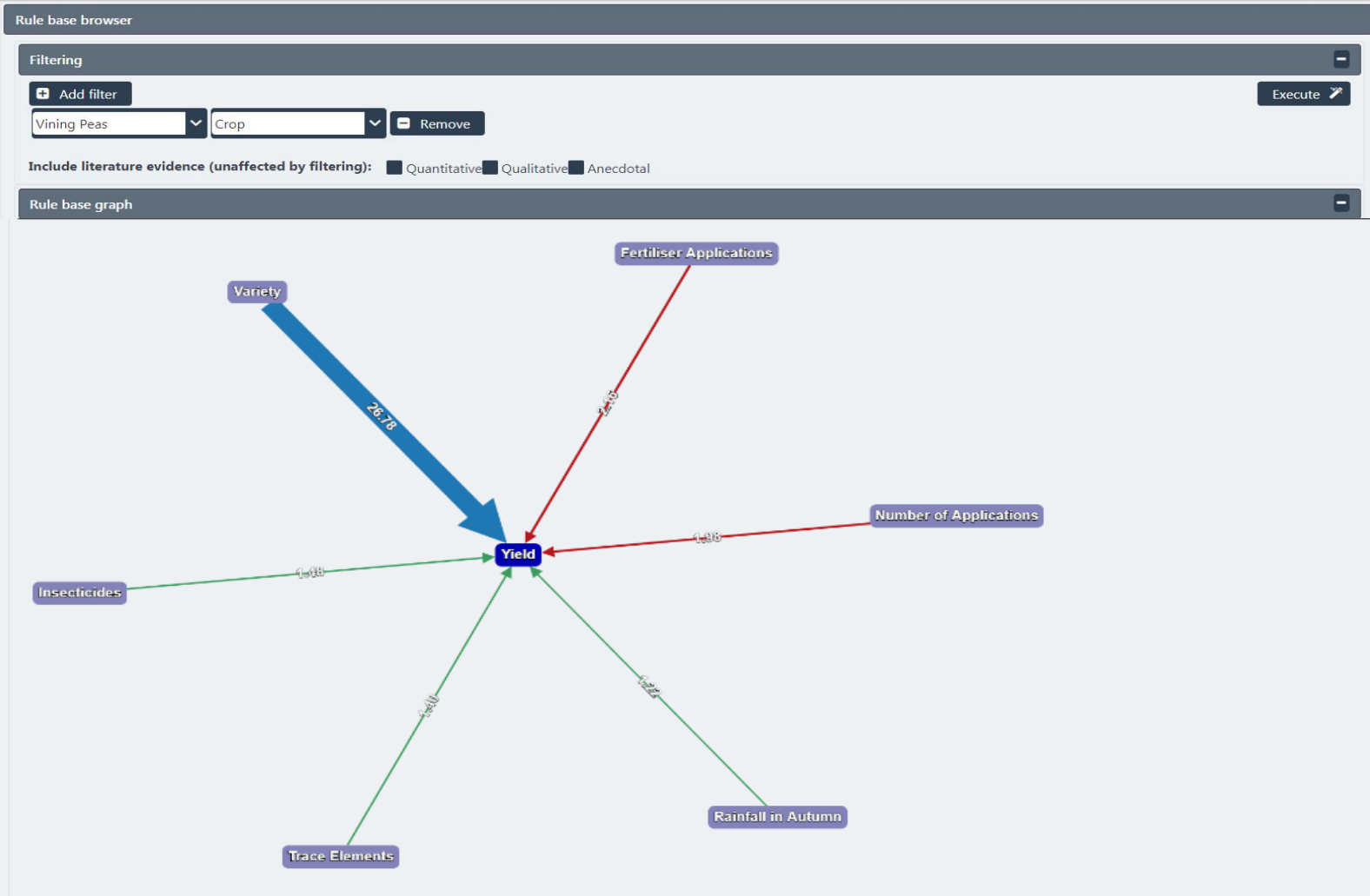


# Potential for natural regeneration



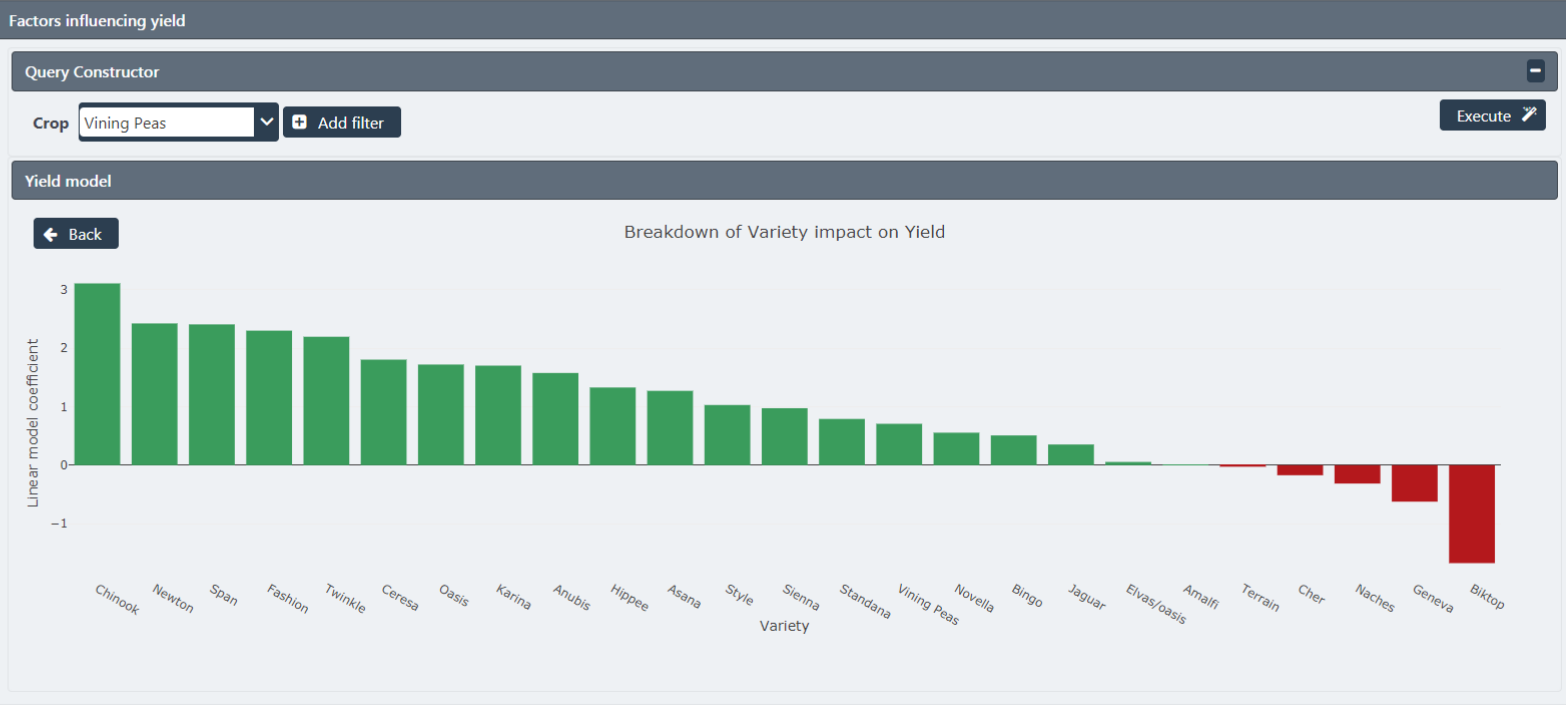
# SMIS Case Studies: Factors affecting Vining Pea yields

- > Browse Database
- > Rule Bases
- > Browse Rule Bases
- > Established Queries

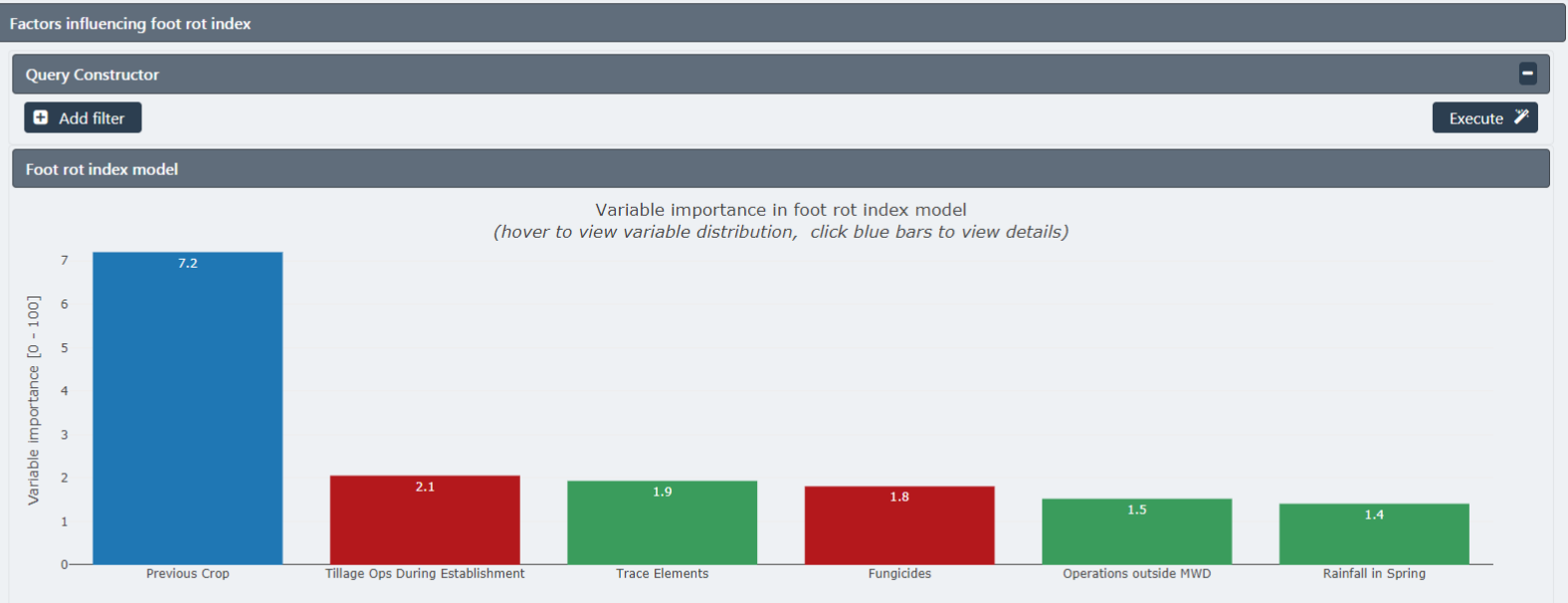


# SMIS Case Studies: Varietal differences in vining pea yields

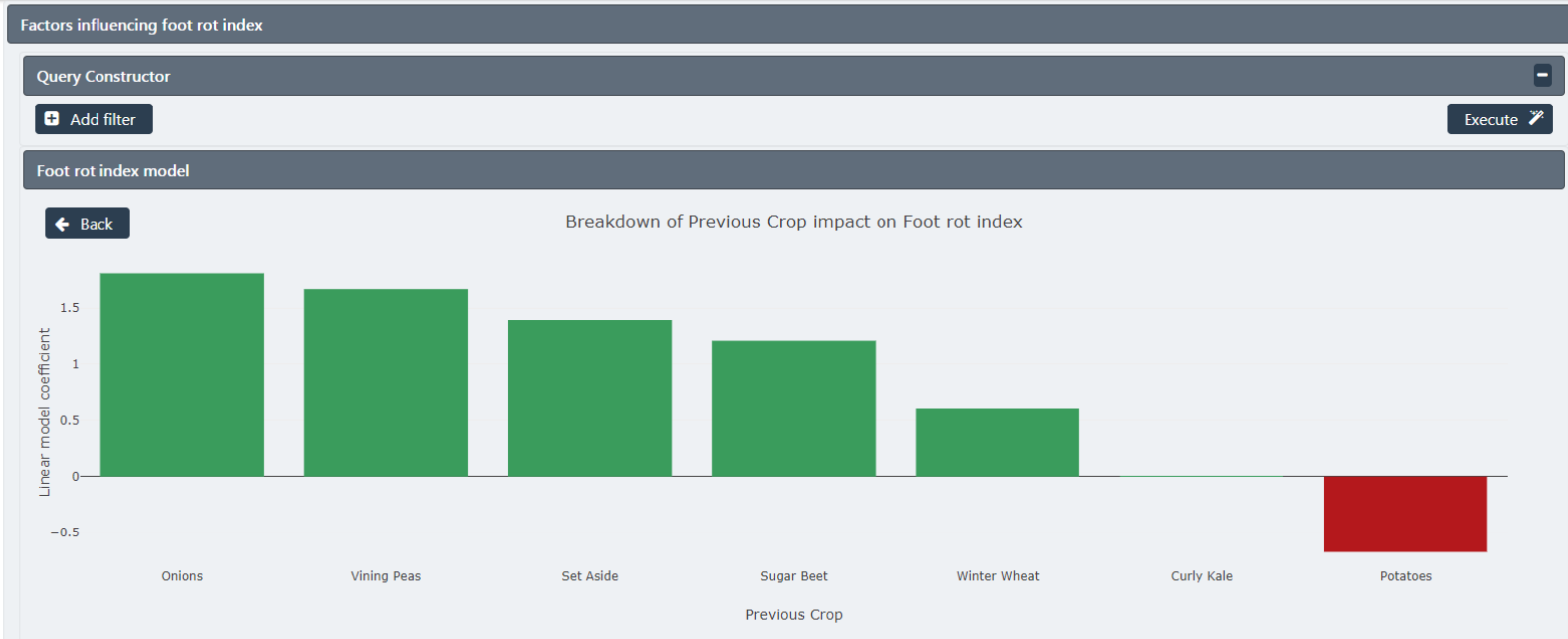
- > Browse Database
- > Rule Bases
- > Established Queries
- > Factors affecting yield
- Competition risk
- Foot rot index
- PCN level
- Cavity spot



- > Browse Database
- > Rule Bases
- Established Queries
- Factors affecting yield
- Compaction risk
- Foot rot index
- PCN level
- Cavity spot

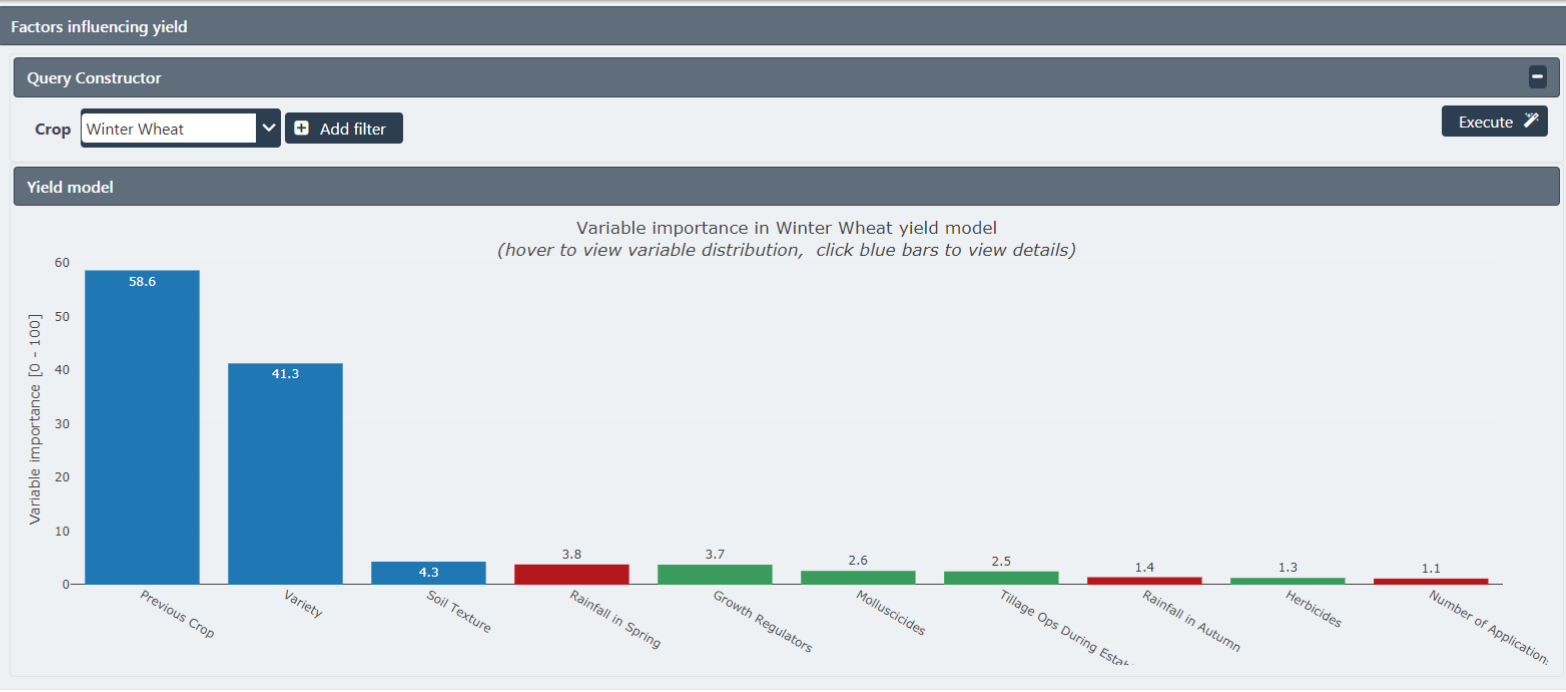


- > Browse Database
- > Rule Bases
- Established Queries
- Factors affecting yield
- Compaction risk
- Foot rot index
- PCN level
- Cavity spot

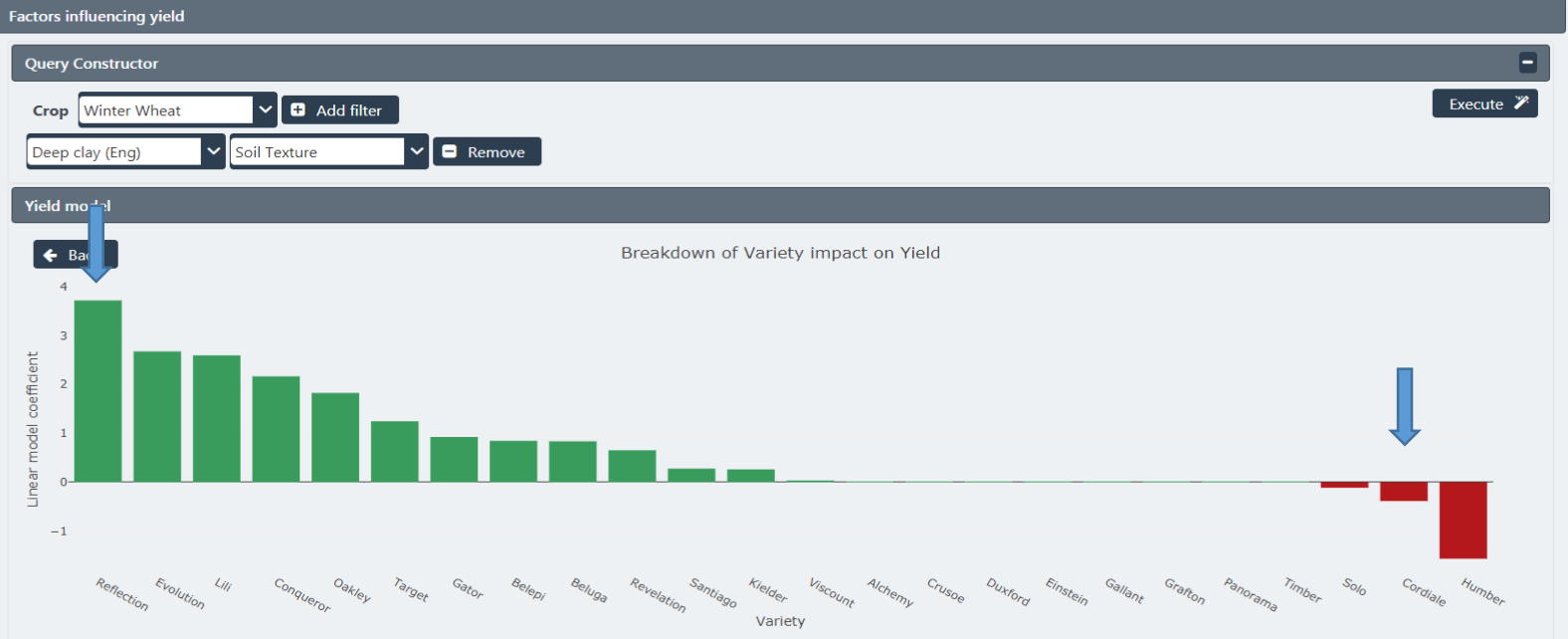


# SMIS Case Studies: Factors affecting Winter Wheat yields

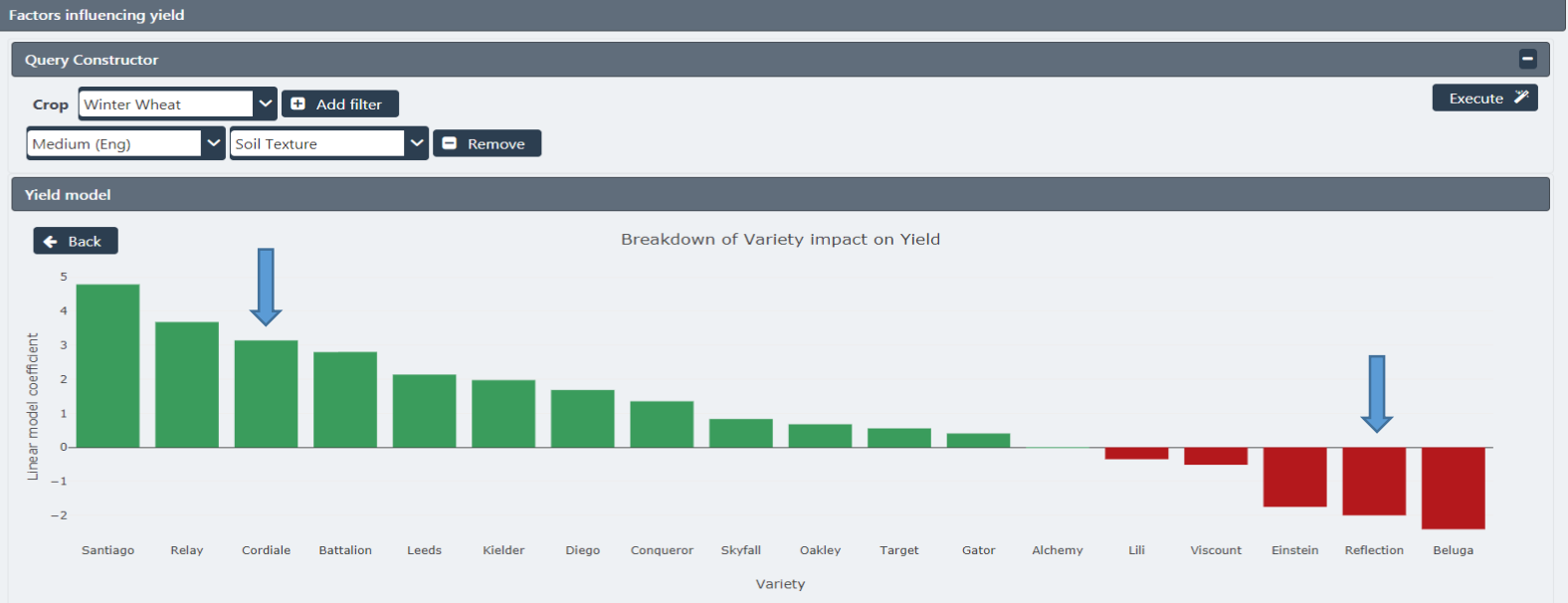
- > Browse Database
- > Rule Bases
- > Established Queries
- > Factors affecting yield
- > Compaction risk
- > Foot rot index
- > PCN level
- > Cavity spot



- > Browse Database
- > Rule Bases
- > Established Queries
- Factors affecting yield**
- Compaction risk
- Foot rot index
- PCN level
- Cavity spot

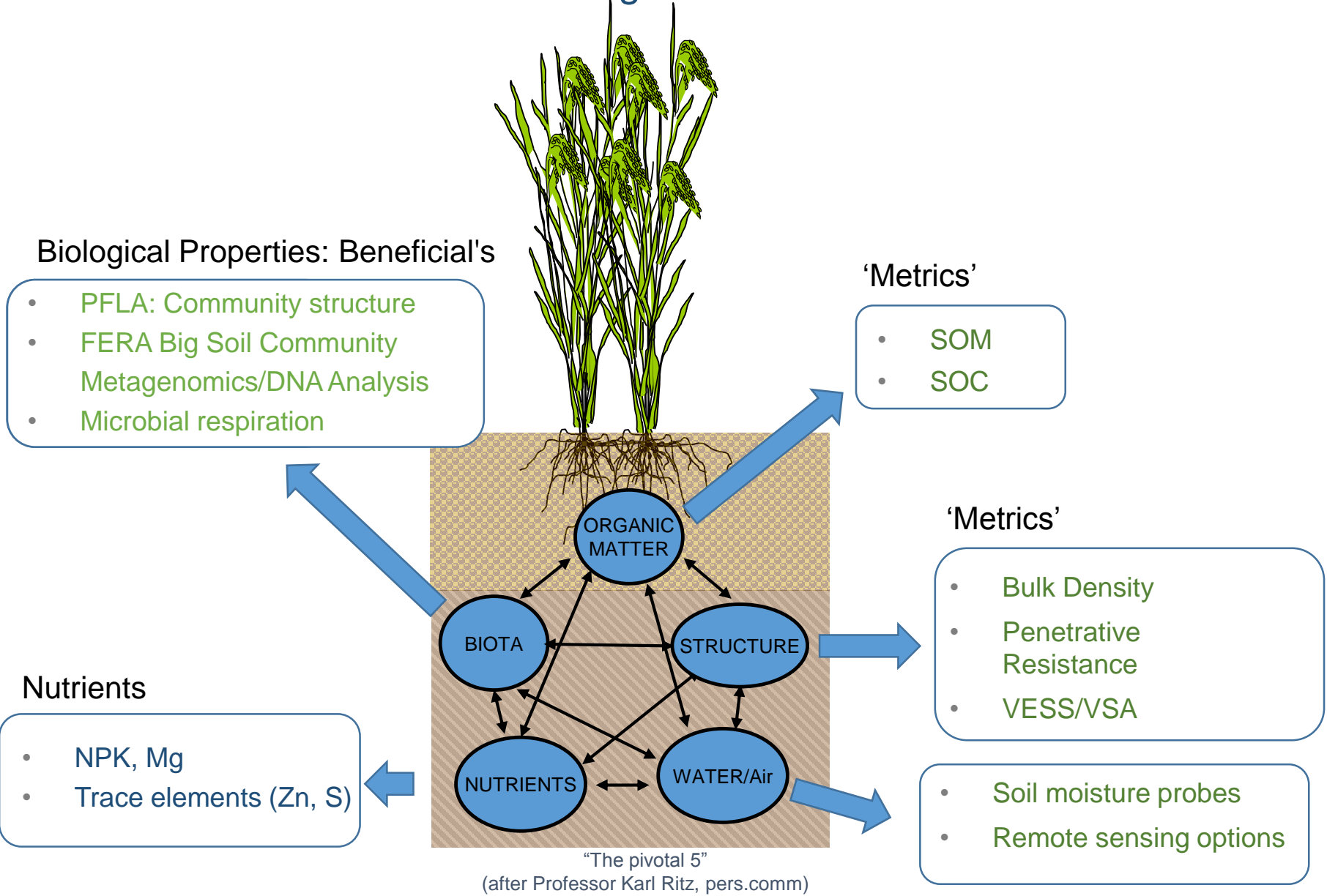


- > Browse Database
- > Rule Bases
- > Established Queries
- Factors affecting yield**
- Compaction risk
- Foot rot index
- PCN level
- Cavity spot





# Metrics of 'soil health': What's missing?





### Acknowledgements:

Many thanks go to the growers who provided data for the development of SMIS as well as their time and inputs in 'sense-checking' data interpretation.

Many thanks also to project partners PGRO for their invaluable inputs/and insights throughout and to AHDB for funding under CP107D

**Dr. Robert Simmons (on behalf of project team)**

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