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AUTHENTICATION

We declare that this work was done under our supervision according to the procedures described herein and that the report represents a true and accurate record of the results obtained.

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CONTENTS

Abstract 1

Introduction 2

Materials and methods 3

Site Location 3

Trial design..3

Soil assessments 5

Cover crop assessments...6

Satellite imaging...6

Results..8

VESS scores 8

Cover crop performance 9

Soil mineral nitrogen analysis 12

Broccoli head nutrient analysis 13

Satellite imaging..14

Discussion 15

Conclusions 16

Knowledge and Technology Transfer 18

Glossary...18

References 18

Appendices 19

Abstract

Conventional broccoli agronomy usually involves leaving fields fallow over winter from the point of harvest in July/August until sowing the next crop the following spring. However, there is increasing evidence that overwintering fields fallow leads to degradation of soil structure and hydrology, causing further negative impacts upon crop growth. There is increasing interest in the use of cover crops for overwintering fields to prevent run-off, nutrient loss and soil degradation and provide other benefits such as the addition of soil nitrogen (N). In this study, multiple mixes of cover crops were tested for their ability to improve several parameters, including soil mineral nitrogen, soil structure and broccoli head nutrition in the subsequent crop. It was concluded that the incorporation of cover crops into the broccoli rotation successfully improved soil structure. A certain cover crop blend, “RAPS” was consistently the most beneficial in terms of dry matter production, N uptake and subsequent N release after destruction. Buckwheat and phacelia cover crops were also seen to be beneficial through improving N uptake and dry matter production, respectively. This study highlights the benefits of including cover crops in broccoli rotations, but also the need for further work in this field, with the recommendation of a repeat study with cover crop replications and assessments from a conventionally bare overwintered field for comparison.

Introduction

For the past two years, AHDB and ADAS have been working with East of Scotland Growers (ESG) in Fife, Scotland, running a series of trials on brassicas, with a particular focus on broccoli in 2021. Rather than continuing with last year's focus on the role of fungicides and herbicides in brassica agronomy, this year's trials included considering the role of cover crops on soil improvement and cover crop and broccoli crop parameters through the season.

Usually, fields used for broccoli planting, which are harvested around July/August, are left fallow until sowing the next broccoli crop in early April. However, there is evidence that this can leave the fields vulnerable to soil erosion, nutrient leaching and run-off, with this detrimental effect on soil structure and quality having a negative effect on crop growth in subsequent seasons, as well as the surrounding environment. There is an increasing interest in the wider agricultural community about the use and benefits of cover crops for over-wintering fields, with evidence that cover crops have the ability to prevent run-off, nutrient loss and soil degradation, with further potential to add extra benefits to the soils (White et al., 2016). This includes the addition of nitrogen (N) into the soil through the inclusion of legumes in the cover crop mix with their N-fixing symbiotic bacteria, and the improvement of soil structure, porosity and drainage through the introduction of plants with a variety of different rooting strategies.

In this study, the growers were interested in determining whether the incorporation of cover crops into a broccoli field improves the soil structure and quality, and whether this has further impacts on improving the yield and quality of the broccoli crop in the following season. Probably the most important factor of interest is how the cover cropping affects N uptake efficiency, as it raises the possibility of being able to reduce N fertiliser usage, or improve application, to benefit crop quality. This is an especially timely topic due to the increasing fertiliser prices in 2021, which are continuing to increase into 2022. A variety of cover crop mixes were used over winter to determine whether different varieties of mixtures were more beneficial than others. There was a particular focus on phacelia and buckwheat as cover crops as they integrate well with broccoli agronomy, working well with planting machinery due to their ease of breakdown. This is an important aspect to consider with the incorporation of cover crops, as excess crop residues to deal with in the spring before planting the broccoli seedlings are ideally avoided.

Materials and methods

Site Location

The field site was based near the village of Carnbee, Fife, Scotland (Figure 1). The cover crop trial was carried out within a section of one field, which was commercially managed and subsequently planted with broccoli targeted for a September harvest by the agronomist James Rome, of East Scotland Growers.

Figure 1. An aerial view from the trial field of the trial site location, along with its location in the United Kingdom. The pin on the field marks the top left corner of the cover crop trial area, at location 56°14’47.4” N, 2°44’53.6” W. Aerial photograph taken by Google in 2021.

Trial design

Seven different cover crop mixes were sown by the grower into the conventionally managed trial field on 18th August 2020. Details of the different cover crop treatments are listed in Table 1, and their sowing location in the field shown in Figure 2. More information on the constituents of the cover crop mixes 3, 4, 5 and 7, which were viterra® cover crop blends, can be found in Figure 3. Treatment 8 (leftover trial mix) is a blend of what was left over from all the above trial mixes once the plots were drilled. Cover crop mixes were supplied by Elsoms from P.H. Petersen, the website of which provided recommended drill rates, which were followed for each blend. One area of the field was left undrilled as a stubble control (marked by blue square in Figure 2). The rest of the field outside of the trial area was left in stubble from the previous cereal crop whilst the cover crop mixes were growing.

Table 1. Cover crop mixes and their grid reference locations for their respective sowing areas. 'Farm standard mix' was a mix of barley and phacelia.

Treatment	Cover crop	Grid reference top left corner of area
1	Control area	Blue area in plan
2	Farm standard mix (barley and phacelia)	56⁰14'47.4"N 2⁰44'53.6"W
3	Bodengare (9 species mix)	56⁰14'47.2"N 2⁰44'53.4"W
4	Universal (4 species mix)	56⁰14'46.9"N 2⁰44'53.3"W
5	RAPS (4 species mix)	56⁰14'46.5"N 2⁰44'52.6"W
6	Black Oats	56⁰14'45.8"N 2⁰44'51.9"W
7	Universal Winter (3 species mix)	56⁰14'45.6"N 2⁰44'51.7"W
8	Leftover trial mixes	56⁰14'44.9"N 2⁰44'50.7"W
	Top right corner	56⁰14'44.4"N 2⁰44'50.1"W

Figure 2. An aerial view of the trial field location showing the areas over which each cover crop mix weas sown. Aerial photograph taken by Google in 2021.

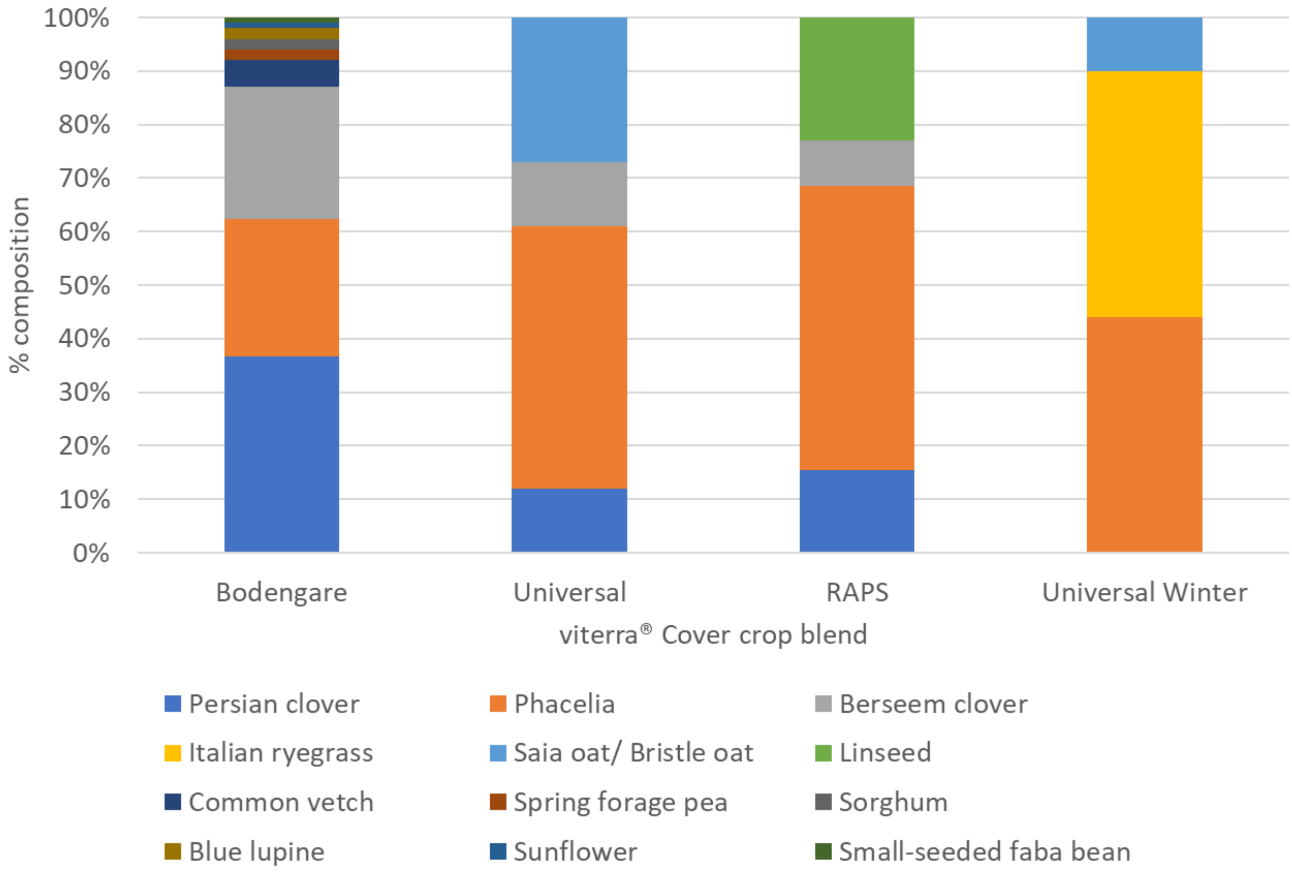


Figure 3. The composition of the viterra® cover crop blend mixes used in this study.

Soil assessments

The VESS (Visual Evaluation of Soil Structure) method of soil structure assessment by SRUC (www.sruc.ac.uk/vess) was used to grade the soil structure under each cover crop. VESS scores between 1 and 2 are classed as 'friable or intact' (no management intervention required), a score of 3 'firm' (review and consider long-term changes), with scores of 4 or 5 'compact' or very 'compact' soils (requiring a change in management). Three VESS assessments were taken in each of the cover crop areas, with the locations determined by undertaking a penetration resistance survey of the area (resistance to 30 cm depth) so that one was undertaken at the point of minimum, median and maximum resistance recorded. Maximum resistance points were consistently found in a sandier ridge through the middle of the cover crop area.

Cover crop assessments

After almost nine months of establishment, the cover crops were sampled for biomass. Due to the particularly cold spring, the cover drops did not grow as well as expected and were therefore sprayed off with glyphosate and cultivated into the soils in May 2021. Buckwheat was then drilled over half of the trial area, and phacelia on the other half at a rate of 6 kg/ha, each covering all the experimental cover crop mix trial strips, to cover the ground until the broccoli was planted in July 2021. At this point, the rest of the field outside the trial area was also drilled with phacelia. Exact dates for the methodology are detailed in Table 2.

Satellite imaging

Satellite images were obtained from the 'Data Farming' website (http://www.datafarming.com.au/) to see if any differences in NDVI (Normalised Difference Vegetation Index) could be seen between treatments. This is a dimensionless index to visualise differences between vegetation cover densities. The cloudless days closest to dates of importance (e.g., drilling, harvesting) were selected to download NDVI imaging data.

Table 2. Detailed diary of the trial methodology

Date	Action
18/08/20	7 different cover crop mixes drilled by grower according to the plan in Fig. 2.
05/05/21	Cover crop biomass samples taken.
07/05/21	Soil samples taken for soil mineral nitrogen (SMN) analysis at 30 cm depth. Min, median and max penetrometer measurements taken to guide VESS assessment locations.
10/05/21	Cover crop fresh weights measured and samples subsampled.
11/05/21	VESS assessments carried out by ESG staff.
14/05/21	Cover crop dry weights measured. Samples sent to NRM for Total Carbon and Total Nitrogen analysis from 1st 7 cover crops. 1st 7 cover crops cultivated in.
20/05/21	Phacelia and buckwheat sown with conventional seed drill.
08/07/21	Phacelia and buckwheat cover crops sampled for biomass and C and N analysis in locations of black oat, RAPS, farm standard mix and control in the 1st set of cover crops due to farmer interest and time constraints. Samples taken for SMN to 30 cm in the same locations.
09/07/21	Phacelia and buckwheat destroyed by spraying off with glyphosate and dead residue strip tilled into the soil.
15-16/07/21	Cover crop dry weights measured. Samples sent to NRM for Total Carbon and Total Nitrogen analysis from phacelia and buckwheat cover crops.
14-17/07/21	Broccoli planted into the tilled strips
30/09/21	Broccoli harvested. Head samples taken for nutrient analysis

Results

VESS scores

The control area in the trial field had a noticeably higher (i.e., poorer soil structure) VESS score at 3.5 compared to soils under all the experimental cover crop mixes. Soils under the cover crop mixes had VESS scores ranging between 2 (Intact) to 3 (Firm), from the best at 2.3 under RAPS to the worst at 2.8 under the Farm standard mix. See Table A.3. in the appendix for the VESS scorecard which describes VESS scores and soil structure quality.

Table 3. The average VESS scores for the control and experimental cover crop mixes. The photographs correspond to the soil sample dug from the corresponding sample, from the medium penetrometer measurement location, both as a solid sample and after being broken up by hand along the natural lines of weakness.

Control – 3.5	**Farm standard mix – 2.8**
	
Bodengare – 2.5	**Universal – 2.5**
	

RAPS – 2.3	**Black Oat – 2.7**
	
Universal winter – 2.5	**Leftover trial mix – 2.5**
	

Cover crop performance

RAPS established with a greater biomass than the other cover crops (Table 4), which resulted in greater N uptake (Figure 4). The enhanced biomass effect seen under RAPS continued when phacelia and buckwheat were drilled into the RAPS experimental strip, compared to experimental strips with different initial cover crops. This increased ease of establishment and speed of growth are important factors to consider when selecting an appropriate cover crop.

N uptake across all first cover crop vegetation mixes were similar (Figure 4). Vegetation sampled from the RAPS cover crop had the greatest N uptake at 42.1 kg/ha and the leftover trial mix had the lowest N uptake at 15.75 kg/ha. The next lowest commercial mix was Bodengare at 19.10 kg N/ha.

After the first cover crop mixes were cultivated in and phacelia and buckwheat drilled in a perpendicular direction over the top, only the C and N content of vegetation in the location of the previous Farm Standard, RAPS, Black Oat and Control mixes were measured due to time constraints. These were selected in discussion with the host grower as those of greatest interest. Overall N uptake was lower in phacelia and buckwheat compared to that achieved by the previous cover crop mixes (Figure 4), most likely due to the shorter growing period, although differences in above ground biomass between the phacelia and buckwheat biomass and previous cover crop mixes were not as great as differences in N uptake. The buckwheat growing in the location of the previous RAPS cover crop had the greatest N uptake at 16 kg N /ha.

The C:N ratio of the cover crops was calculated, to determine how easily the plant material is likely to break down and release N into the soil. The optimum C:N ratio for desired decomposition in crop residue is 24:1 (24 units of carbon to 1 unit of nitrogen), as its beneficial for microbial health and activity (USDA, 2011). Material with a higher C:N ratio, such as wheat straw at 80:1, causes soil microorganisms to remove nitrogen from the soil. Material with a C:N ratio lower than 24 will decompose quickly, with excess N becoming available in the soil for growing plants. From the first set of cover crop mixes, the C:N uptake ratio was lowest in the Universal and RAPS mixes and greatest in the Universal Winter mix, probably due to the large proportion of ryegrass and relatively low legume content. The C:N ratios were much lower across all buckwheat and phacelia treatments, decreasing from an average of 28.4. to 9.5 (Table 4), possibly due to the lower maturity of the plants. This lower C:N ratio is much more likely to create available N for growing plants, rather than immobilising it.

Table 4. Biomass and C:N ratio results for under the first and second set of cover crops.

Cover crop	Biomass (t/ha)	C:N	1st cover crop	2nd cover crop	Biomass (t/ha)	C:N
Farm standard mix	5.85	28.51	**Farm standard mix**	**Buckwheat**	2.80	9.71
Bodengare	5.90	25.17		**Phacelia**	7.53	9.48
Universal	5.34	23.56	**RAPS**	**Buckwheat**	5.79	9.10
RAPS	15.29	24.63		**Phacelia**	12.19	10.00
Black Oat	7.29	26.77	**Black oat**	**Buckwheat**	3.99	10.29
Universal winter	8.12	36.03		**Phacelia**	8.00	8.91
Leftover trial mix	4.76	33.99	**Control**	**Phacelia**	15.64	8.978

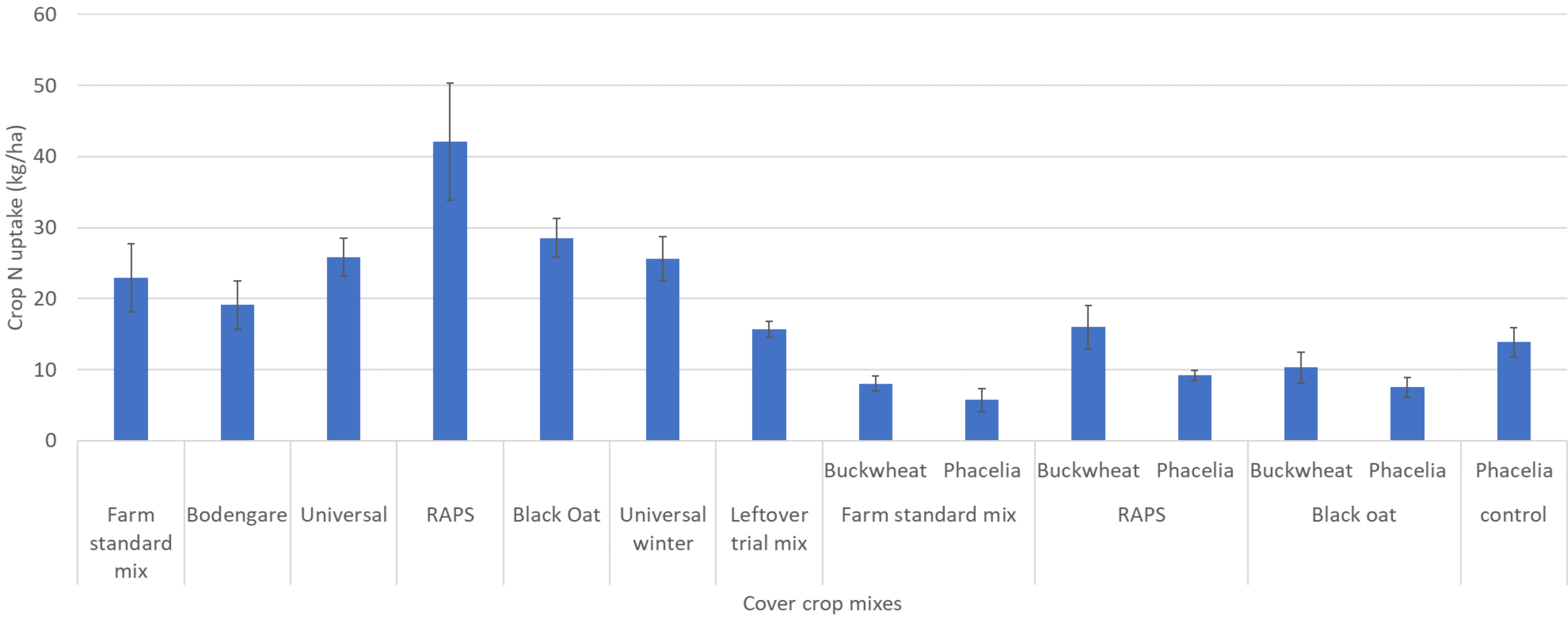


Figure 4. Crop nitrogen uptake by the first and second set of cover crops, measured in kg/ha.

Soil mineral nitrogen analysis

After the first set of cover crop mixes, soil mineral N (SMN; kg/ha) to 30 cm depth was low (<20 kg/ha), particularly under the farm standard mix and Universal winter mixes (< 5 kg/ha; Figure 5a). After buckwheat and phacelia were drilled into the first cover crop mixes, SMN increased substantially, with soil under RAPS as the first cover crop followed by phacelia containing the highest available N at 82 kg N/ha, compared to 13 kg N/ha N following the RAPS cover crop (Figure 5b). This could indicate release of N from the previously incorporated RAPS cover crop, which had the highest biomass and N uptake of all the previous cover crops grown. This sampling was also carried out after a period of warmer weather, which is known to enhance mineralisation of soil organic matter and cover crop residues. Data for Nitrate N (mg/kg) and ammonium N (mg/kg) for both first and second cover crops, plus greater depth measurements for the first cover crop mixes, can be found in the appendices (Table A.1 and A.2).

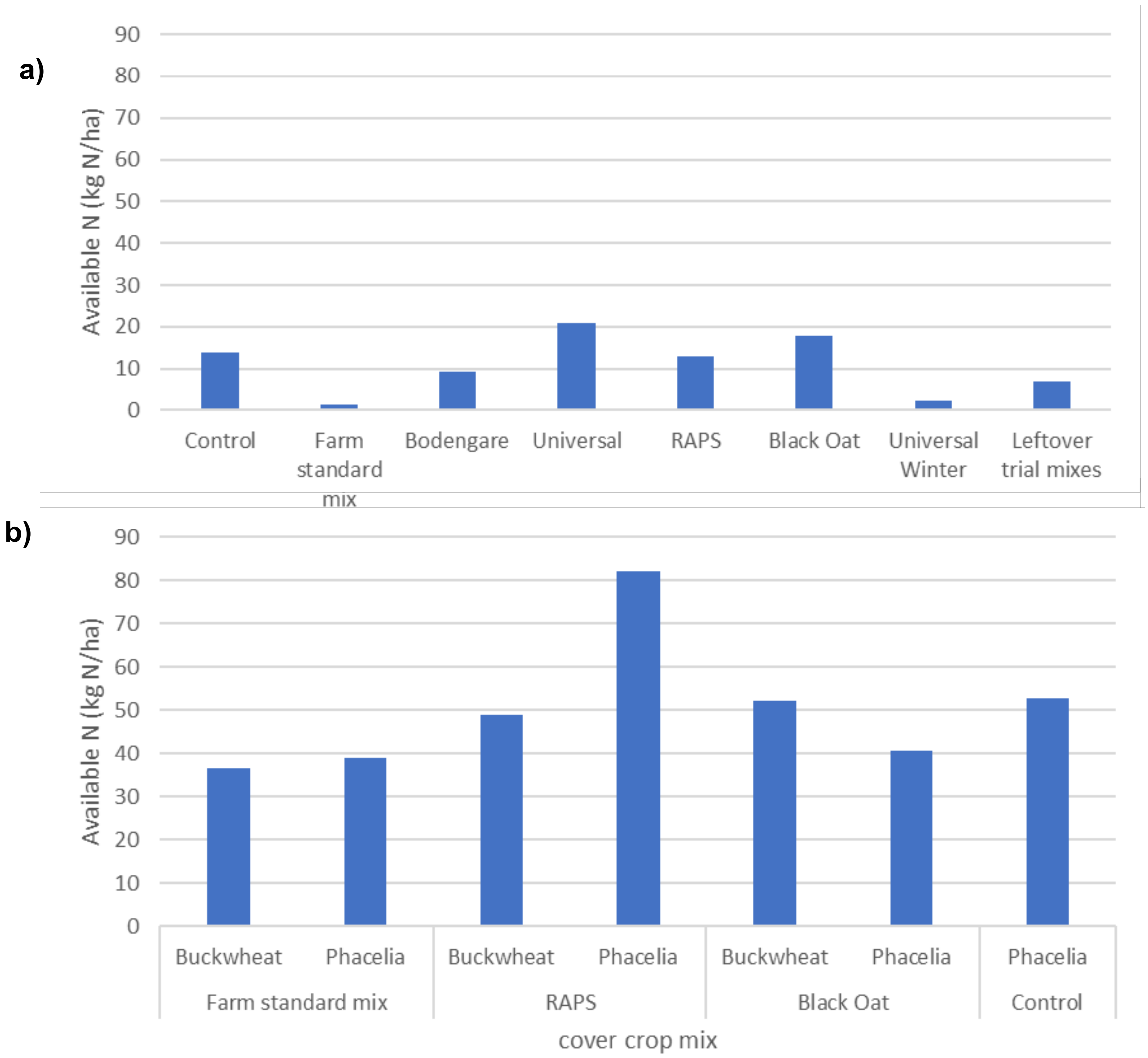


Figure 5. SMN (kg/ha) after the first (a) and second (b) set of cover crops (0-30 cm depth).

Broccoli head nutrient analysis

Broccoli heads harvested from the trial area which was sown previously with buckwheat after the first set of cover crops had higher nutrient content in all measured nutrients except for potassium, where broccoli harvested from the trial area sown with phacelia was greater (Table 5). There was a notable increase in total phosphorus with nutrient content of the heads increasing by nearly 1000 mg/kg of total P. There is evidence that buckwheat can increase the release of phosphorus, and therefore uptake, and these results would also indicate this.

Table 5. Results of the broccoli head nutrient analysis, comparing between those grown in the area under buckwheat and those under phacelia.

Post 2nd cover crop	Total Nitrogen	Total Phosphorus	Total Potassium	Total Calcium	Total Magnesium	Total Sulphur	Total Manganese	Total Copper	Total Zinc	Total Iron	Total Boron
	% w/w	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Buckwheat	5.55	6573	39142	4463	2186	9691	38.6	15.6	53.9	66.1	30.4
Phacelia	5.28	5668	40340	4176	2112	9112	31.4	12.6	49.7	64.8	28.5

Satellite imaging

Satellite images from several dates are shown in Figure 6. The image taken on 12th August 2020 is the closest image available to before the date when the cover crop mixes were drilled into the field on 18th August 2020. The whole field is bare at this point, giving a baseline colour of NDVI image for a field without any green leaf area. The image taken on 1st July 2021 is the image closest to the date of sampling for the phacelia and buckwheat cover crops on 8th July 2021. The greatest NDVI is towards the North of the field, at the top of the cover crop trial area and also in the non-trial area. The image taken on 29th September 2021 is taken the day before the broccoli crop was harvested on 30th September 2021, which is quite even throughout the entire field.

12th August 2020 | **1st July 2020** | **29th September 2021**

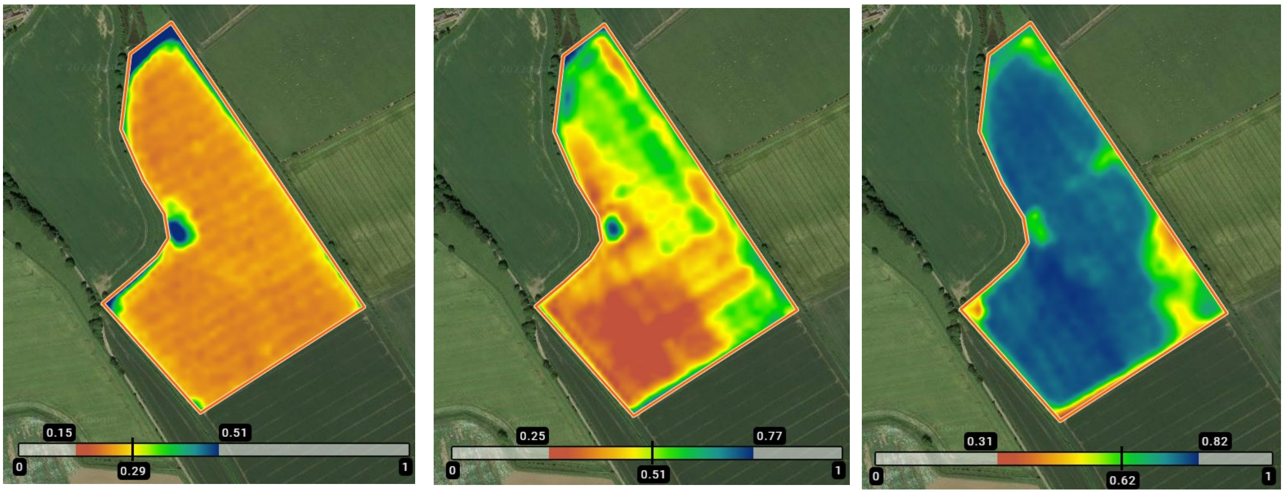


Figure 6. Satellite images taken on the closest cloudless days to dates of interest, such as drilling and harvesting. The colours show NDVI ((Normalised Difference Vegetation Index), which is a measure of green leaf area. Images taken with permission from Data Farming (http://www.datafarming.com.au/).

Discussion

This study gives an insight into the impacts of using a cover crop in overwintering fields before broccoli cropping, as opposed to the usual practice of leaving fields fallow. The VESS scores reduced from 3.5 in the stubble control, indicating firm to compact soils requiring a change in management, to between 2-3 in the cover cropped areas, which was deemed acceptable. This indicates that using a cover crop as opposed to leaving the field in stubble from the previous crop had a positive impact on soil structure. This is likely due to the active roots under the cover crops creating pores and channels as well as holding the soil structure together, which can disaggregate and become sensitive to compaction under inactive stubble roots. The absence of an actively growing crop on the stubble control is also potentially detrimental to the microbial and earthworm communities which also benefit soil structure. In addition, gleying was observed in the control treatment, and lack of breakdown of straw, which indicates an anaerobic environment.

Out of the different cover crop mixes, the viterra® cover crop blend 'RAPS' seemed to be the most beneficial. The cover crop RAPS produced the greatest biomass and had the highest N uptake out of the first cover crop mixes, with this benefit continuing under the phacelia and buckwheat secondary sown cover crops, with buckwheat dry matter production and N uptake greatest following the previous RAPS mix compared to the other mixes. SMN was also highest under phacelia which had previously been sown with RAPS.

The RAPS mix consisted of 53% phacelia, 23% linseed, 16% Persian clover and 8% Berseem clover. It is described as being particularly beneficial for N fixation due to the clovers, with protection against soil erosion due to its dense rooting and suitable for crop rotation with cereal and oilseed rape due to being free from crucifers. This also makes it very suitable to be used in broccoli rotation. Due to RAPS being a relatively simple mix, dominated by phacelia and linseed, these two species are likely to have established well and quickly. On the other hand, the Bodengare mix had a much greater number of species, which did not seem to relate to greater functionality. It also contains a greater proportion of legumes which can be slow to establish.

Regarding buckwheat and phacelia as cover crops, broccoli heads following buckwheat had higher percentages in all nutrients except potassium, which was higher following phacelia. Cover crop N uptake and biomass production tended to be higher for buckwheat compared to phacelia. However, the impact of phacelia compared to buckwheat on SMN is inconclusive as there were no visible trends.

The satellite imagery data was also inconclusive as there were no differences between the different cover crop mixes from the image taken on 1st July 2021, seven days before the sampling of the buckwheat and phacelia cover crops. In fact, the largest difference in NVDI seemed to be the perpendicular to the cover crop trial lines, with the south-west of the field having a lower NDVI compared to that in the north-east. This is likely due to the topography of the undulating field, which is described as 'lighter and gravelly over the hill with a greater clay fraction at the bottom' (south-west area). This topography can be visualised from the photograph in Figure 7, which shows how the land dips into the south-west of the field, which could cause changes in soil structure and hydrology, which can have a down-stream impact on NDVI.

Figure 7. The in-field view facing to the south-west of the field, showing the bottom of the cover crop trial area, which had a lower NDVI than the rest of the trial area.

Conclusions

In conclusion, the incorporation of cover crops into the broccoli rotation over winter improved the soil structure, determined by an improvement in the VESS score. Out of the cover crop mixes trialled, RAPS seemed to be the most beneficial in terms of dry matter production, N uptake and subsequent N release after destruction. The following buckwheat also performed better than the phacelia (in terms of N uptake but not dry matter production) and an improved broccoli head nutrient status in all nutrients except potassium. The data provided in this report supports the use of cover crops for improving soil structure with mixes containing clovers and phacelia being particularly good at taking up N. However, further work is required in order to understand whether this uptake translates into an increased N uptake and N use efficiency in the broccoli crop following cover cropping. Although the satellite imagery did not detect any green area differences in the broccoli crop, no detrimental effects were observed from where the broccoli was grown over the cover crop experimental area compared to the conventional stubble in the rest of the field.

Since there were no replicates of cover crop mixes included in this study, and assessments undertaken from a conventionally bare overwintered field, it would be recommended that this study is repeated with cover crop replicates and controls to confirm the observations and trends seen in this study.

Knowledge and Technology Transfer

Training was provided to the staff at East of Scotland Growers (ESG) to use the VESS assessment to determine soil structure (Figure 8). The ESG team then carried out VESS assessments to provide data that was used in this report.

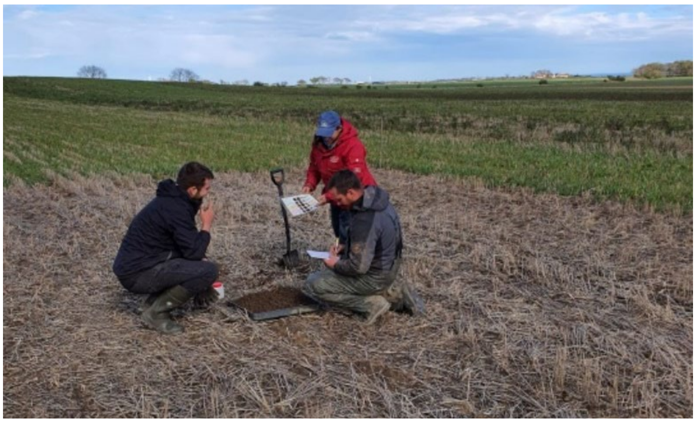


Figure 8. Angela Huckle providing VESS assessment training to ESG staff.

Glossary

NDVI: Normalised Difference Vegetation Index.

SMN: Soil Mineral Nitrogen

VESS: Visual Evaluation of Soil Structure

References

USDA Natural Resources Conservation Service. (2011). *Carbon to Nitrogen Ratios in Cropping Systems*. http://www.nm.nrcs.usda.gov/Technical/tech-notes/agro/

White, C., Holmes, H., Morris, N., & Stobart, R. (2016). A review of the benefits, optimal crop management practices and knowledge gaps associated with different cover crop species. In *Research Review No. 90*. https://www.researchgate.net/publication/311788892_A_review_of_the_benefits_optimal_crop_management_practices_and_knowledge_gaps_associated_with_different_cover_crop_species

Appendices

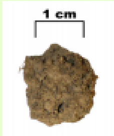
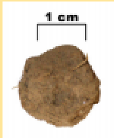
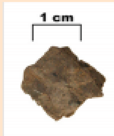
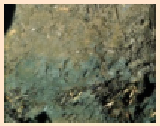
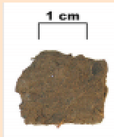
Table A.1. Raw SMN data for 0-90 cm depth profiles after the first cover crop set

Cover crop mix	Depth profile (cm)	Nitrate N (mg/kg)	Ammonium N (mg/kg)	Available N (kg/ha)
Control	0-30	3.13	0.59	14
	30-60	2.07	1.17	12.2
	60-90	1	0.38	5.2
Farm standard mix	0-30	0.06	0.35	1.5
	30-60	0.81	0.06	3.3
	60-90	0.68	0.07	2.8
Bodengare	0-30	2.18	0.33	9.4
	30-60	1.89	0.63	9.4
	60-90	2.84	0.34	11.9
Universal	0-30	5.03	0.53	20.8
	30-60	2.36	0.35	10.1
	60-90	2.97	0.4	12.6
RAPS	0-30	2.46	1.01	13
	30-60	0.79	0.33	4.2
	60-90	0.38	0.38	2.9
Black Oat	0-30	4.4	0.36	17.8
	30-60	2.74	0.07	10.5
	60-90	0.66	0.07	2.7
Universal Winter	0-30	0.06	0.56	2.4
	30-60	1.46	0.06	5.7
	60-90	0.68	0.37	4
Leftover trial mixes	0-30	1.75	0.07	6.8
	30-60	1.49	0.06	5.8
	60-90	0.62	0.06	2.5

Table A.2. SMN data after the second cover crop of buckwheat and phacelia after the first 7 cover crop mixes. Available N as kg N/ha is estimated assuming the standard depth of 30 cm for soil N profiling.

1st cover crop	2nd cover crop	Nitrate N (mg/kg)	Ammonium N (mg/kg)	Available N (kg/ha)
Farm standard mix	Buckwheat	9.41	0.35	36.6
	Phacelia	10.08	0.29	38.9
RAPS	Buckwheat	12.65	0.42	49
	Phacelia	21.14	0.73	82
Black Oat	Buckwheat	13.43	0.47	52.1
	Phacelia	10.5	0.29	40.5
Control	Phacelia	13.76	0.27	52.6

Table A.3. The VESS scorecard used by ESG to determine soil structure (accessed from www.sruc.ac.uk/vess).

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.

