Interreg
EUROPEAN UNION
France (Channel Manche) England
Channel Payments for Ecosystem Services
European Regional Development Fund

CPES

Field demonstration of the efficacy of cover crops to reduce nitrate leaching : 2019-20

Date/Version: November 2020

Redactor: Dr Anne Bhogal (ADAS)

Contact: anne.bhogal@adas.co.uk

ADAS

Phacelia & oat cover crop mix; December 2019

The INTERREG VA France (Channel) England programme is financed through the European Regional Development Fund (ERDF).

Overview

This study aims to demonstrate the feasibility of growing cover crops ahead of spring cropping as a means of reducing over-winter nitrate leaching losses from the shallow chalk soils found across much of Portsmouth Water's catchment area. As well as assessing the impact on water quality, the study will also evaluate the effect of cover cropping on subsequent spring crop yields and gross margins in order to demonstrate the impact for the whole farm business. The work is being undertaken on a commercial farm in Hampshire over three cropping seasons (2018-2021), with a new field selected each season according to the host farmer's crop rotation (i.e. a field that is scheduled for spring barley).

Cover crop treatments and assessments

Three cover crop treatments (Table 1) were drilled in August 2019 along a 100m length of a single 'tramline' width (36m) on a shallow silty clay loam soil over chalk (depth to chalk: *c.* 40cm). The cover crop species were selected to give a 'simple' low cost option (oats) compared to a mix that would qualify for an Ecological Focus Area green cover (EFAGC) payment (oats & phacelia), with both options compared to an untreated stubble (which became a weedy stubble during the course of the winter). The cover crops were established using a single pass of the farm 'Bio Drill' mounted on a 'Top Down' cultivator. This comprised a combination of discs working to 30mm depth, followed by a set of tines working to 120-140mm depth, followed by a set of levelling discs after which the seed was broadcast and finally rolled.

Table 1. Cover crop treatments

Treatment	Description
1	Conventional practice (bare/weedy stubble)
2	Cereal (oats) cover crop (@40 kg/ha)
3	EFA mix: cereal (oats) and phacelia (ratio 9:1 @ 40 kg/ha)

Soil samples were taken to 40cm depth in October 2019 to measure soil mineral nitrogen (ammonium-N & nitrate-N: SMN) content and porous ceramic water samplers were installed to *c.*40cm depth (12 per tramline) to measure nitrate concentrations in drainage water (sampled every 2 weeks or after 25mm drainage). The measured concentrations were combined with drainage volumes estimated using the IRRIGUIDE model to calculate over winter nitrate leaching losses. SMN was also measured in January 2020 prior to cover crop destruction, and combined with measurements of cover crop nitrogen (N) uptake to quantify the soil nitrogen supply (SNS) to the following spring barley crop.

Winter 2019-20 results

Both the oat and phacelia/oat cover crops established well and produced *c.*40% and *c.*70% cover, respectively by January 2020, compared to the control treatment where weeds/volunteer cereals produced a cover of *c.*30% (Plate 1). By January 2020, the phacelia/oat mix had produced *c.*1.6 t/ha dry matter and taken up *c.*43 kg/ha nitrogen compared to 1.0 t/ha dry matter and 37 kg/ha uptake by the oat cover crop, and <0.5 t/ha dry matter and 13 kg/ha N uptake on the control treatment. In contrast to the previous year, there were no severe over-night frosts during winter 2019-20, so Phacelia (which can be sensitive to frost) remained for the duration of the winter and the whole site was sprayed with glyphosate to destroy all the vegetation at the end of January 2020. High rainfall in February (148 mm compared to the 30 year (1981-2010) average of 51mm) delayed drilling of the spring barley crop until the end of March 2020.

Plate 1. Treatment tramlines in January 2020: a) Oats; b) Weedy stubble; c) Phacelia & oats

Nitrate leaching losses winter 2019-20

Winter 2019-20 was characterised by exceptionally high rainfall, with a total of 854 mm falling between September and March (compared to 520 mm recorded over a similar period on farm over winter 2018-19 and a 30 year average for this period taken from the Met office station at Thorney Island of 469mm). This led to *c.*500 mm drainage (estimated using the Irriguide model), compared to *c.*300 mm over winter 2018-19. The phacelia/oat cover crop was very effective at reducing nitrate leaching losses, with just 3 kg/ha N lost by leaching and an average (flow-weighted) nitrate-nitrogen (NO_3-N) concentration in the drainage water of 0.6 mg NO_3-N/l (Figures 1 & 2). Nitrate leaching losses from the oat cover crop were *c.*12 kg/ha with an average concentration of 2.4 mg NO_3-N/l, and the control (no/low ground cover) *c.*25 kg NO_3-N /ha, with an average concentration of 5.1 mg NO_3-N/l in the drainage waters. There was some evidence of increased nitrate-N concentrations in the drainage after cover crop destruction on 30/1/20 (Figure 2), but throughout the winter drainage season all nitrate-N concentrations were below the EU limit of 11.3 mg NO_3-N/l.

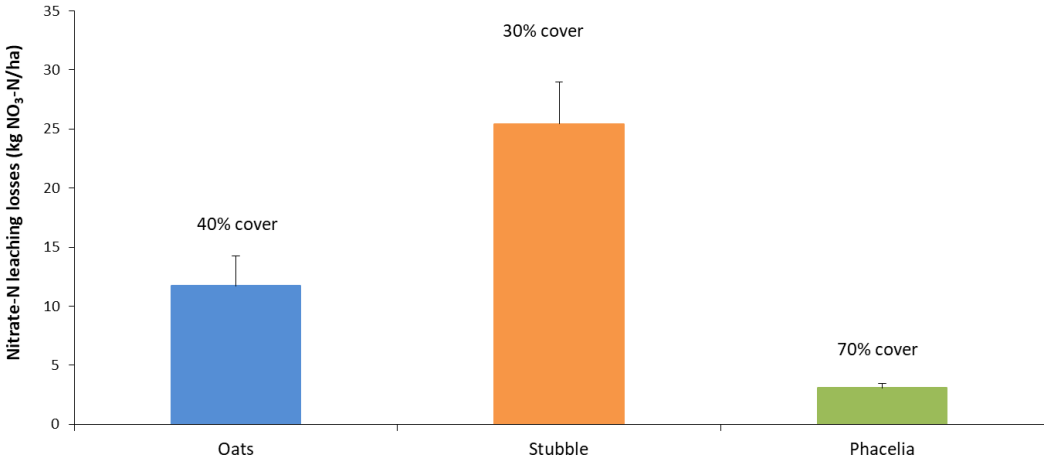

Figure 1. Nitrate leaching losses October 2019-February 2020 (854 mm rainfall; 500 mm drainage).

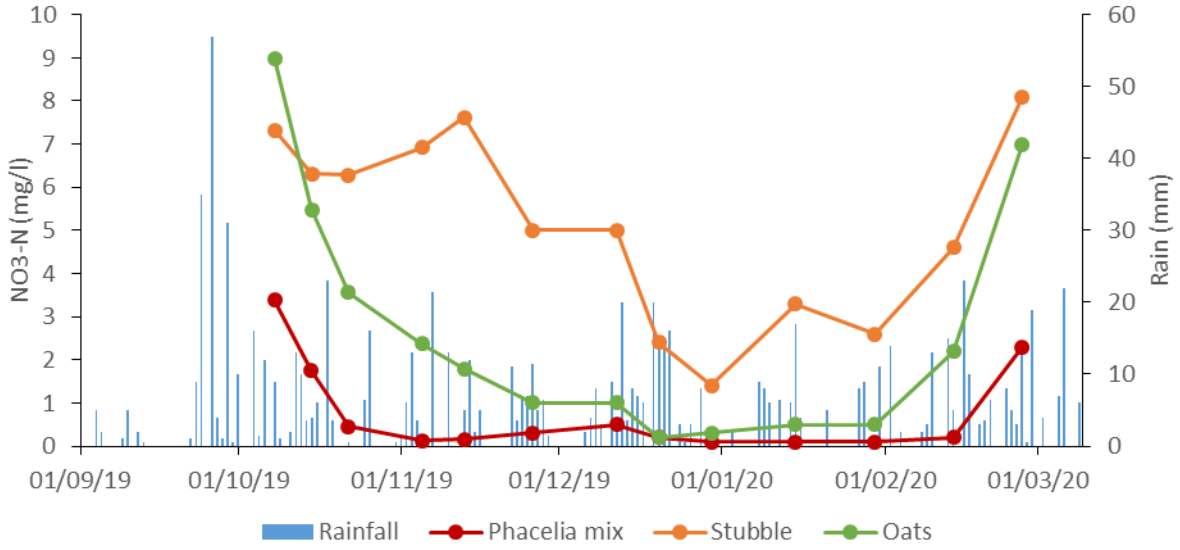

Figure 2. Nitrate concentration of the drainage waters and rainfall October 2019-March 2020 (cover crop destroyed 30/1/20)

Retention of N by the cover crops resulted in more nitrogen potentially available for the following spring barley crop (compared to the control). Soil N supply (SNS = cover crop N + soil mineral N) was *c.*55-60kg/ha on the cover crop treatments, compared to *c.*35 kg/ha on the control (Figure 3). However, these differences were not considered to be sufficient to warrant a change in N fertiliser policy for the following spring barley crop. This is in contrast to the demonstration carried out in 2018-2019, where SNS following the phacelia cover crop mix was 75 kg/ha and fertiliser applications following this cover crop were reduced by 30 kg/ha.

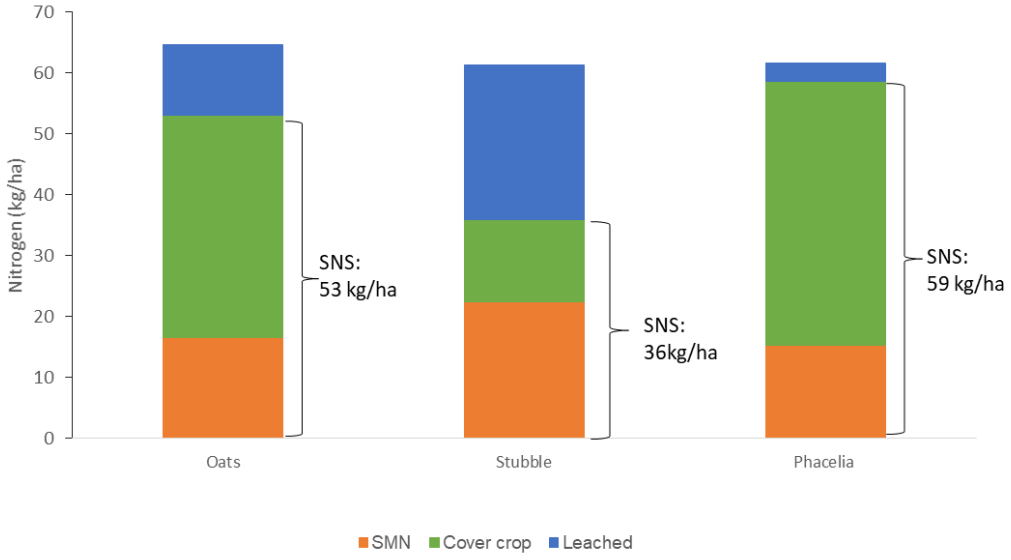

Figure 3. Nitrogen present in the soil, crop and lost by spring 2020 (*c.* 25-30 kg/ha was present in the soil in autumn 2019); SNS = soil nitrogen supply (potentially available for use by the following spring barley crop).

Spring barley grain yields and nitrogen content

The spring barley was harvested in early August (8/8/20) using a yield mapping combine (Figure 4). There was no apparent difference in yield as a result of the cover crop treatments, with yields ranging from 7.9 ± 0.2 t/ha following the oat cover crop to 8.2 ± 0.4 t/ha following the phacelia cover crop and an overall average for the experimental area of 8.1 t/ha (Table 2). Grain nitrogen content and nitrogen offtake were higher following the cover crops, although in the absence of replication it is not possible to determine if these results are statistically significant.

Table 2. Spring barley yield and grain nitrogen content (2020); 95% confidence limits in brackets

Treatment	Mean yield (t/ha @ 85% dm)	Grain N (%)	Grain N offtake (kg/ha)
1. Control (stubble)	8.25 (± 0.11)	1.70	117
2. Oats	7.91 (± 0.19)	1.86	125
3. Phacelia/Oats mix	8.16 (± 0.37)	1.89	131

Number of yield records = 29 on the control and 23 each on the cover crop treatments; single sample analysed for grain N.

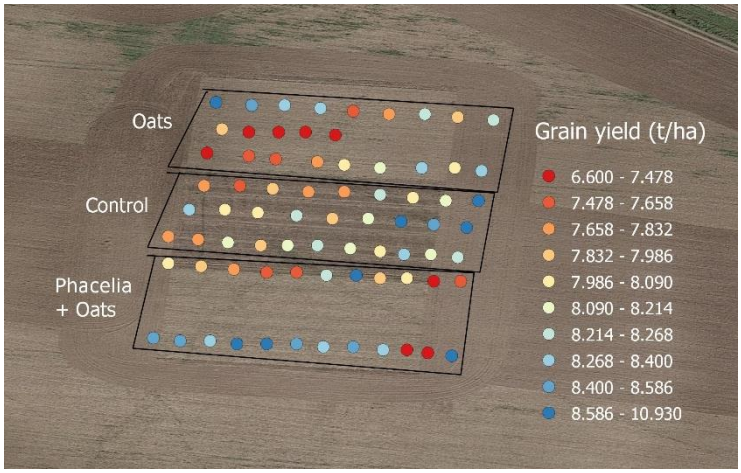

Figure 4. Spring barley yield map, August 2020

Cost/Benefit analysis

A simple cost-benefit assessment was produced for each of the treatments, based on the various operations and inputs performed by the host farmer and using costs/prices that the farmer incurred (Table 3). As there was no apparent difference in grain yield, the experimental area average of 8.1 t/ha was used in the analysis. In contrast to 2018-19 there was no saving in N fertiliser as a result of the cover crop treatments, so gross margins were higher on the control treatment due to the absence of costs associated with purchase of the cover crop seed. This together with the additional operational costs associated with establishing the cover crop resulted in net margins £80-£90/ha lower for the cover crop treatments. The phacelia and oat cover crop mix would, however, qualify for a 'Greening Payment' as an 'Ecological Focus Area – EFA' under the Basic Payment Scheme. To count as an EFA, farmers can grow a cover crop mix comprising of at least one cereal (oats, rye or barley) and one non-cereal (vetch, phacelia, mustard, Lucerne or oilseed radish), established by 1st October and retained until 15th January. The value of the greening payment depends on the payment region and application year; in 2019 this was €78.69/ha (c. £70/ha). Applying this would have reduced the loss in margin associated with growing the phacelia/oat cover crop mix, to *c.*£20/ha. Greening payments will end in England next year, as the agricultural transition commences and the country moves towards the new Environmental Land Management Scheme - ELMS (expected to start in 2024). An alternative means of recuperating the cost of establishing a cover crop could be to enter the land into Countryside Stewardship (option SW6 'winter cover crops' – which currently pays £114/ha).

Table 3 Cost/benefit of the different cover crop options

Treatment	Stubble	Oats	Phacelia/Oats
Yield (t/Ha)	8.1	8.1	8.1
Price (£/t)	142	142	142
OUTPUT (£/Ha)	1150	1150	1150
Cover crop seed		8	19
Barley Seed	8	85	85
Fertiliser - N	130	130	130
Sprays	128	128	128
Total variable costs	343	351	362
GROSS MARGIN (£/Ha)	**807**	**799**	**788**
FIELD OPERATIONAL COSTS (£/ha)			
Cultivate & drill covers		50	50
Rolls (x1)		20	20
Barley cultivate & drill	50	50	50
Fertiliser (x2)	20	20	20
Cover crop/weed sprayer (x1)	10	10	10
Barley sprays (x4)	40	40	40
Combining	90	90	90
Total Operational Costs (£/ha)	210	280	280
NET MARGIN (£/Ha)	**597**	**519**	**508**

Conclusions – year 2

The residual soil mineral N levels were considerably lower post-harvest ahead of the winter 2019/20 drainage season (< 30kg/ha SMN to 40cm, compared to 80-110 kg/ha SMN to 60cm in 2018). Over-winter nitrate leaching losses were consequently lower than measured the previous year (maximum loss of 25 kg/ha, compared to 60 kg/ha in 2018/19), despite higher rainfall and drainage volumes. However, in both seasons, the phacelia/oat cover crop mix was very effective at reducing nitrate leaching losses to negligible levels (80-90% reduction in N losses across both seasons), with a clear relationship becoming apparent between the percentage crop cover and nitrate loss.

There was also no detrimental effect of growing the cover crop on the yield of the spring barley, but net margins were *c.* £80-90/ha lower compared to growing no cover crop. The reduced margin reflected the cost of establishing the cover crop, with the differences in soil N supply not sufficient to justify adjusting N fertiliser rates. Applying for the BPS EFA greening payment would have reduced the costs of the phacelia treatment, but this payment will not be available from 2021 due to the transition towards the new ELMS in England.