Interreg France (Channel Manche) England

EUROPEAN UNION

Channel Payments for Ecosystem Services

European Regional Development Fund

CPES

Field demonstration of the efficacy of cover crops to reduce nitrate leaching : 2018-19

Date/Version: October 2019

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ADAS

Phacelia cover crop

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 before the establishment of spring crops to reduce nitrate leaching losses from the shallow chalk soils found across much of Portsmouth Water's catchment area. The study will also evaluate the effect of cover cropping on subsequent spring crop yields and gross margins. 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 2018 along a 100m length of a single 'tramline' width (36m) on a shallow silty clay loam soil over chalk ('Andover' soil series). The project compared a 'simple' low cost option (oats) with a mix that would qualify for an Ecological Focus Area green cover (EFAGC) payment (oats & phacelia). Both options were 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 60cm depth at cover crop drilling to measure soil mineral nitrogen (ammonium-N & nitrate-N: SMN) content and porous ceramic water samplers were installed to *c.*60cm 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 February 2019 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 2018-19 results

The phacelia cover crop grew well, and quickly produced up to 90% crop cover (Plate 1), compared to the oats which established poorly (most likely due to the dry conditions at drilling), and only produced *c.*30% cover. There was a good weed/volunteer cereal population on the stubble treatment producing *c.*40% cover. By January 2019, the phacelia had produced *c.*1.5 t/ha dry matter and taken up *c.*50 kg/ha nitrogen compared to just 0.3 t/ha dry matter and 10 kg/ha uptake by the oat cover crop. Phacelia can be sensitive to frost, and a night-time temperature of -6°C in late January caused it to wilt and die over the next 10 days. The whole site was sprayed with glyphosate in early February to destroy the oats and weeds, cultivated using the farm 'Top-Down' cultivator (disc & tine working to *c.* 120mm) and spring barley was drilled in early March 2019.

Plate 1. Treatment tramlines in January 2019: a) Oats; b) Weedy stubble; c) Phacelia & oats

Nitrate leaching losses winter 2018-19

The phacelia cover crop was very effective at reducing nitrate leaching losses, with just 10 kg/ha N lost by leaching and an average (flow-weighted) nitrate-nitrogen (NO_3-N) concentration in the drainage water of 3 mg/l (Figures 1 & 2). The weedy stubble lost *c.*30 kg/ha with an average concentration of 11 mg/l (the EU nitrate-N limit for drinking water is 11.3 mg/l NO_3-N), and the poorly-established oat cover crop *c.*60 kg NO_3-N /ha, with an average concentration of 21 mg/l NO_3-N in the drainage waters (i.e. almost double the EU limit).

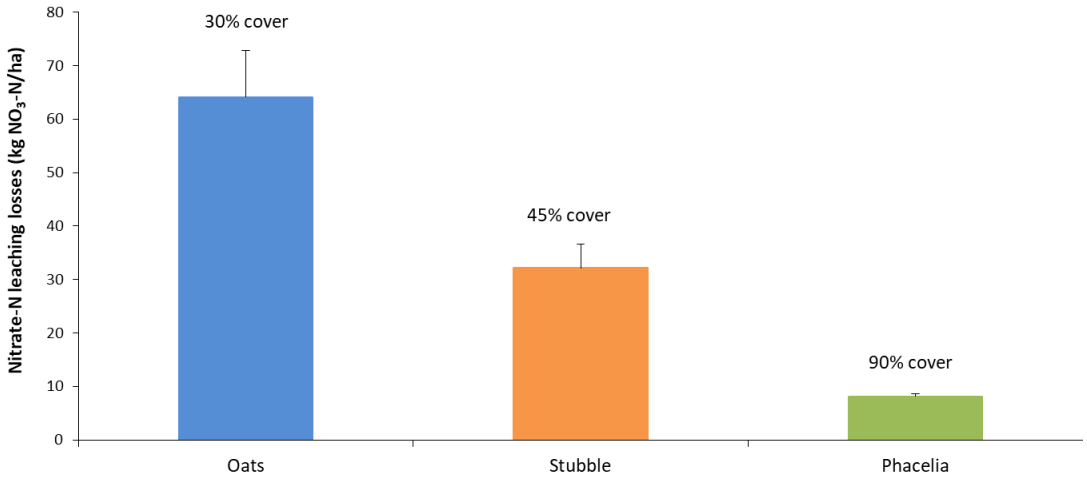

Figure 1. Nitrate leaching losses October 2018-March 2019 (520 mm rainfall; 270-300mm drainage).

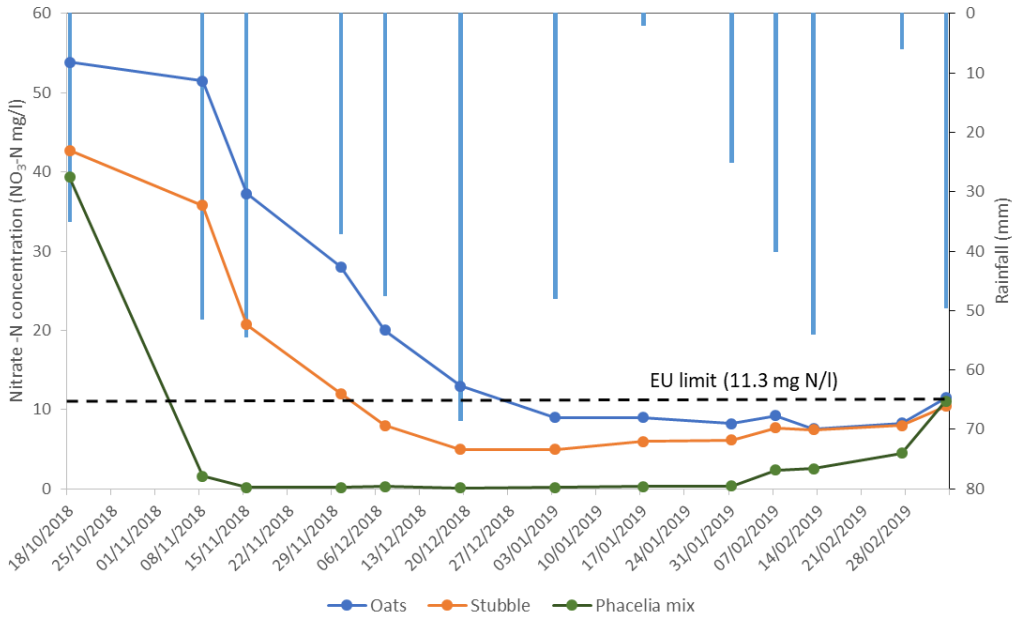

Figure 2. Nitrate concentration of the drainage waters and rainfall October 2018-March 2019

The reduction in nitrate leaching losses resulting from the phacelia cover crop increased the potential crop available nitrogen supply to the following spring barley crop by over 35kg/ha compared to the other cover crop treatments (Figure 3). As a result, the amount of nitrogen fertiliser applied to the spring barley was reduced by 30 kg/ha. The SNS of the stubble and oat treatments was not sufficient to warrant a change in fertiliser policy for these two treatments.

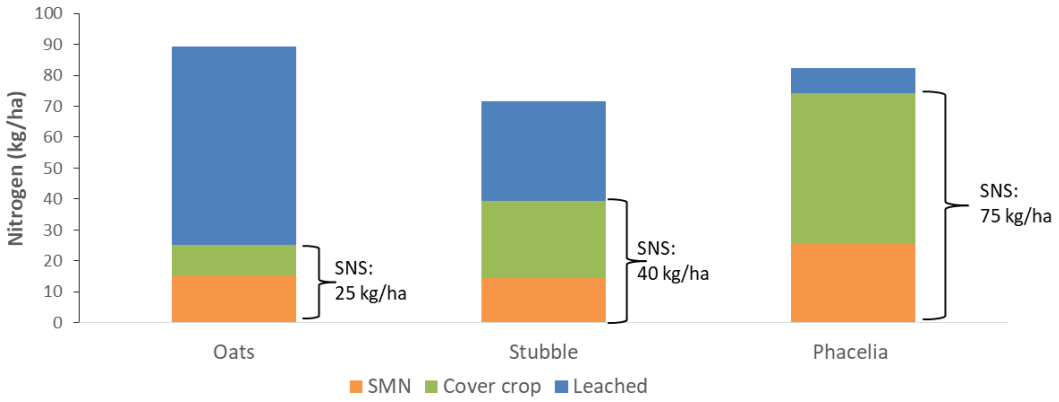

Figure 3. Nitrogen present in the soil, crop and lost by spring 2019 (*c.* 80-110 kg/ha was present in the soil in autumn 2018); SNS = soil nitrogen supply (potentially available for use by the following spring barley crop).

Spring barley grain yields and nitrogen content

The spring barley was harvested in late August (28/8/19) using a yield mapping combine. This map was analysed by the ADAS Agronomics statistical model in order to ascertain whether any yield differences were a result of the different cover crop treatments or due to other sources of variation such as soil variability across the field (Figure 4). The control (no cover crop) treatment had an average yield of 8.25 t/ha (@85% dry matter), according to yield map data. The modelled effect of the oat cover crop was to reduce yields by 0.1 t/ha and the phacelia/oat cover crop to increase yields by 0.2 t/ha (Table 2), although the statistical model indicated that a yield difference of this size was probably

the result of underlying spatial variation rather than the cover crop treatments; a yield difference in excess of 0.40 t/ha would be required in order to have a statistically significant treatment effect at the 95% confidence level; Table 2).

The grain nitrogen content was 1.59% following the phacelia cover crop, 1.67% following the oat cover crop and 1.73% on the control (stubble only) treatment.

Table 2. Spring barley yields (2019) as recorded using yield mapping with statistical analysis using Agronomics to predict the effect of the cover crop treatments

Treatment	Mean yield (t/ha @ 85% dm)	Difference in yield from the control treatment (t/ha with 95% confidence limits)
1. Control (stubble)	8.25	
2. Oats		0.11 ± 0.40
3. Phacelia/Oats mix		0.18 ± 0.40

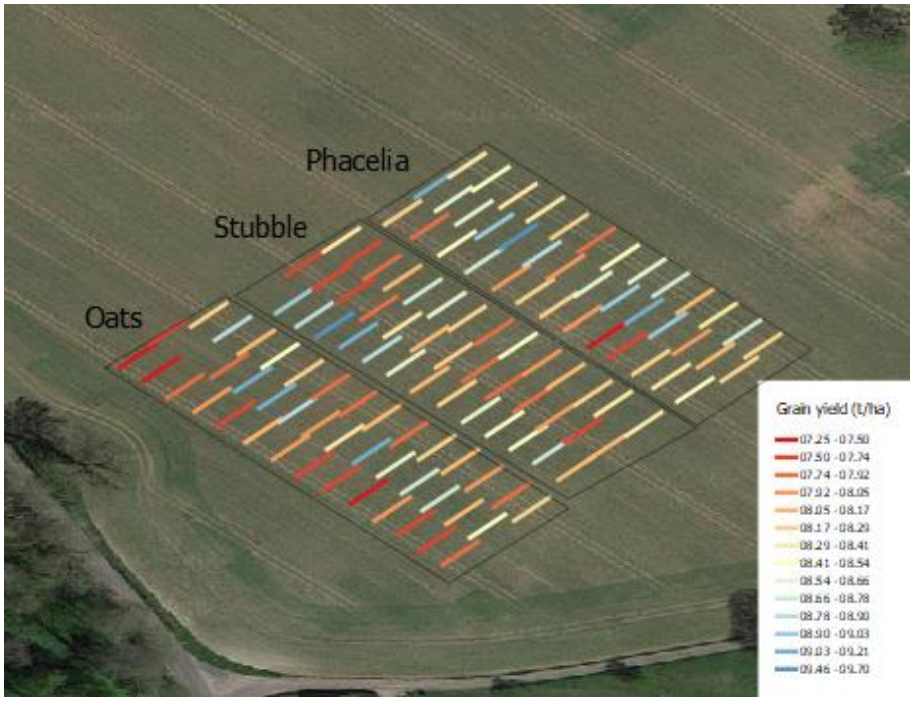

Figure 4. Spring barley yield map, August 2019

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 actual costs/prices that the farmer incurred (Table 3). Although the grain yields were marginally higher where phacelia had been grown, this was not statistically significant, so a single grain yield of 8.3 t/ha (site average) was used in the analysis. However, as the phacelia treatment required less N fertiliser (due to the higher nitrogen capture over winter and hence spring soil N supply), this treatment had a slightly higher (£5/ha) gross margin relative to where no cover crop had been grown (£806/ha compared to £801ha). However, the cover crop establishment costs (seed plus operational costs), amounted to £70/ha on this treatment and reduced the net margin to below that of the stubble treatment. 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 for farmers. 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 the land is in and application year; in 2018 this was €78.13/ha (£69.76/ha). Therefore, if the farmer claimed this greening payment, the cost of growing the cover crop would have been recovered and the farmer would have broken even (£5/ha net benefit).

The oat cover crop, although cheaper to establish, did not perform well, with no fertiliser savings for the following spring barley crop, which together with low grain yields, gave rise to the lowest net margin (Table 3). This treatment would also not qualify for an EFA greening payment.

Table 3 Cost/benefit of the different cover crop options

Treatment	**Stubble**	**Oats**	**Phacelia/Oats**
Yield (t/Ha)	8.3	8.3	8.3
Price (£/t)	135	135	135
OUTPUT (£/Ha)	1121	1121	1121
Cover crop seed		8	18.6
Barley Seed	82	82	82
Fertiliser - N	101	101	76.5
Sprays	137	137	137
Total variable costs	320	328	314
GROSS MARGIN (£/Ha)	**801**	**793**	**806**
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)	**591**	**513**	**526**

Conclusions – year 1

The phacelia cover crop mix was very effective at reducing nitrate leaching losses (by 2/3rds compared to the stubble treatment), retaining nitrogen in the cropping system and reducing the inorganic N fertiliser inputs to the following spring barley crop. There was also no detrimental effect of growing the cover crop on the yield of the spring barley, but net margins were *c.* £65/ha lower compared to growing no cover crop due to the cost of establishing the cover crop. However, applying for the BPS EFA greening payment, increased the gross margin of the phacelia treatment to £5/ha more than the gross margin of the stubble treatment.