Professional Nutrient Management Group

Update report on nutrient management planning

October 2018

Summary

This is the fourth in a series of reports on nutrient management planning and practices for the Professional Nutrient Management Group (PNMG).

The main sources of statistical data were the series of Farm Practices Surveys published by Defra (Defra 2018a), the annual British Survey of Fertiliser Practice (BSFP 2018) and collations of soil analysis results by the Professional Agricultural Analysis Group (PAAG 2017). Much of the data used are for England, some for Great Britain and some for the UK.

Positive trends were apparent in several aspects of nutrient management:

Industry-supported advisory schemes continued to expand. More than 3500 FACTS Qualified Advisers and 1000 Feed Adviser Register members now provide nutrient management advice throughout the UK.

Application of sulphur to arable crops has increased to compensate for greatly reduced emission from industry and deposition to land. In 2016/17, 80% of the oilseed rape area and 55-70% of the cereal area received sulphur in manufactured fertilisers. This should largely prevent lack of sulphur from restricting nitrogen use efficiency in these crops.

Nitrogen use efficiency (NUE), measured as the ratio of crop output to fertiliser nitrogen applied, continued to increase in potatoes, oilseed rape and sugar beet. NUE in grassland, measured as the ratio of livestock population to amount of fertiliser nitrogen applied, also continued to increase.

Uptake of precision farming techniques continued to increase steadily.

There were other aspects of nutrient management where there appears scope for improvement and where advisory efforts might be concentrated:

Utilisation of manure nutrients could be improved in several ways. More widespread use could be made of standard tables or laboratory analysis for estimating the nutrient content of manures. More account could be taken of nutrients applied in manures, especially phosphate and potash, when decisions are made on use of manufactured fertilisers. Manure spreaders could be calibrated more frequently.

While the number of routine soil samples taken from arable land seems relatively satisfactory, it appears that more use could be made of the test results. The proportion of samples showing target index for both P and K has been just 9-10% for many years and greater convergence on these indices seems possible.

Use of lime could be improved. In the PAAG report for 2016/17 soil pH was lower than 6.0 in 16% of arable samples and lower than 5.5 in 18% of grassland samples. Lime use has decreased steadily and in 2017/17 the amount applied was around half the estimated annual loss from soils of 4.25 million tonnes $CaCO_3$.

While the use of fertiliser sulphur on grassland has increased, it remains small relative to the known responsiveness to sulphur of grass cut for silage.

Nitrogen use efficiency in wheat has remained stable in recent years in contrast to the increasing trends in potatoes, oilseed rape and sugar beet.

Contents

1.0 Introduction

In 2010, the Professional Nutrient Management Group (PNMG) commissioned a report to

i. collate and report evidence of nutrient management planning during the period following publication of the Tried & Tested nutrient management plan;

ii. review this information in the context of historical data;

iii. identify gaps in advice and support on nutrient management planning.

The *Report on nutrient management planning* was published in September 2010. This clarified the terms 'nutrient management', 'nutrient management planning' and 'nutrient management practices'. Follow-up reports, were published in January 2013 and July 2015. All of these reports are available at the Tried & Tested web site www.nutrientmanagement.org. This is the fourth report in the series, and deals with recent developments in nutrient management planning and practices.

2.0 Source of data

The main source of statistical information on nutrient management planning was the series of Farm Practice Surveys conducted by Defra (Defra 2018a). The surveys sample farms in England above certain sizes (50 cattle, 100 sheep, 100 pigs, 1000 poultry or 20 ha of arable crops or orchards) so might not reflect fully practices on all farms or in the UK as a whole. The 2018 survey sampled 6000 of the 60,000 eligible farms with a 40% response rate.

Items directly relevant to nutrient management planning were included in surveys from 2006 though not all items were included every year. Coverage of nutrient management became more comprehensive and consistent from 2009.

Farm Practices Survey data are analysed routinely on a holding basis with results reported as percentage of holdings. From 2014, some nutrient management items have been analysed also on an agricultural land area basis. Usually, but not invariably, reported values were greater on a land area than on a holding basis.

Data also were available from the annual British Survey of Fertiliser Practice (BSFP 2018), Defra Farm Business Survey (Defra 2018b), AIC statistics and reports of the Professional Agricultural Analysis Group (PAAG 2018).

3.0 Nutrient management planning

3.1 Uptake of nutrient management plans in 2018

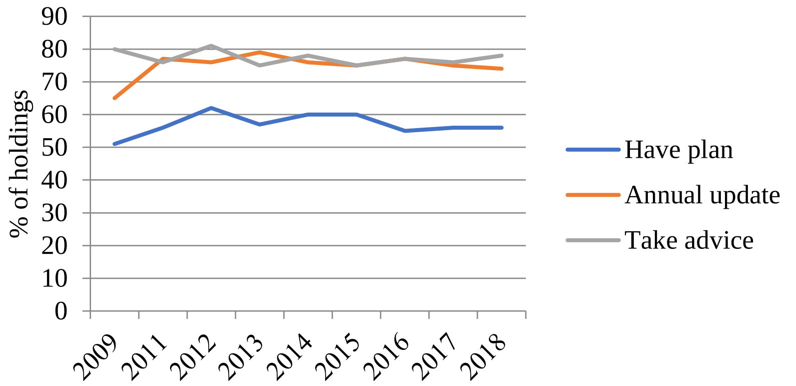
In 2018, 56% of all farms surveyed (in England), covering 74% of the farmed area, reported having a nutrient management plan. This percentage was lowest among small and grazing livestock farms (Table 1). 76% of farms reported taking professional advice in producing a nutrient management plan and 74% updated their plan annually. These percentages have been fairly stable over the past ten years (Fig 1).

Table 1 Uptake of nutrient management planning in 2018
(% of all holdings, % of farmed area in parentheses)

	Have nutrient management plan	Take professional advice for NMP	Annually update NMP
Small	47 (62)	74 (77)	73
Medium	62 (66)	76 (76)	74
Large	76 (84)	78 (79)	75
Cereals	81 (90)	84 (84)	87
Other crops	83 (91)	83 (86)	84
Pigs and poultry	38 (79)	66 (67)	77
Dairy	71 (80)	77 (79)	69
Grazing (LFA)	22 (33)	49 (57)	36
Grazing (lowland)	35 (50)	59 (63)	55
Mixed	66 (77)	77 (71)	68
All farms	56 (74)	76 (78)	74

Source: Defra Farm Practices Survey

Fig 1 Nutrient management plans
(Source: Defra Farm Practices Survey)



3.2 Uptake of nutrient planning tools

Of the methods used to produce a nutrient management plan, PLANET remained in widespread use, especially among larger farms, despite not having been updated to the new Nutrient Management Guide (RB209) (Table 2). The popularity of PLANET is likely to decline as the recommendations and default values it embodies diverge from those in the Nutrient Management Guide.

The hardcopy-based Tried & Tested Nutrient Management Plan was more popular than PLANET, Muddy Boots or Farmade/Multicrop among grazing livestock farms, 18-19% of which reported using this method to produce a plan (Table 2).

Results of the Farm Practices Survey were reported on both number of farms and farmed area bases though reported values differed little.

Table 2 Method of creating a nutrient management plan in 2018
(% farms with a plan, % land area in parentheses)

Farm size	PLANET	Muddy Boots	Farmade/ Multicrop	Tried and Tested	Other	Don't know
Small	19 (20)	19 (20)	11 (14)	16 (14)	32 (30)	15 (12)
Medium	23 (21)	16 (18)	11 (14)	19 (16)	30 (33)	12(10)
Large	28 (30)	17 (17)	12 (17)	16 (16)	27(26)	12 (10)
Cereals	26 (30)	17 (18)	18 (23)	15 (14)	26 (25)	12 (9)
Other crops	23 (27)	26 (25)	16 (21)	18 (13)	20 (23)	12 (10)
Pigs and poultry	23 (23)	18 (17)	11 (18)	11 (7)	30 (35)	18 (10)
Dairy	29 (33)	10 (14)	3 (3)	16 (13)	31 (28)	15 (14)
Grazing (LFA)	9 (6)	3 (1)	0 (0)	18 (11)	59 (62)	17 (21)
Grazing (lowland)	17 (21)	14 (10)	5 (6)	19 (31)	43 (33)	12 (8)
Mixed	17 (21)	32 (27)	5 (13)	17 (19)	23 (21)	16 (8)
All farms	23 (26)	18 (18)	11 (16)	16 (15)	30 (28)	13 (10)

3.3 Uptake of advice (FACTS, FAR and CSF)

Professional advisers are important as they assist farmers in nutrient management planning and they have a magnifier effect on uptake of some planning tools and on the likelihood of changing practices. A proportion, probably a large proportion in some cases, of these planning tools is used by advisers rather than directly by farmers. Numbers of these tools distributed therefore can lead to underestimates of their impact. This probably applies especially to PLANET, MANNER and Nutrient Management Guide (RB209) where the adviser can use one copy of the tool on behalf of several farmers. The magnifier effect will be less for paper-based plans like Tried & Tested that are one copy per farm (but the adviser can be a distributor for these tools, so promoting their use).

Advisers on nutrient management include those employed by organizations (commercial companies, Environment Agency, Defra, Natural England) or working as farm consultants (often members of AICC or BIAC). Most nutrient management advisers who deal directly with farmers are now FACTS Qualified Advisers or members of the Feed Advisers Register or of both.

FACTS: FACTS (www.basis-reg.com, www.factsinfo.org.uk) was established in 1992 firstly to help ensure an adequate level of technical knowledge in UK crop advisers who dealt with nutrient management. As the scheme developed, attention moved to the steady improvement of this level of knowledge. A technical information service was introduced in the late 1990s to give FACTS advisers access to nutrient management expertise (via phone and email help-lines) and to a large library devoted to nutrient management. Since 2001, a quarterly technical newsletter has been sent to advisers by email. The information service allows messages and new information to be disseminated rapidly and cheaply to almost all farm advisers dealing with crop nutrition.

FACTS Qualified Advisers must provide evidence of continuing professional development to maintain their status. This is done by accumulating a minimum number of cpd points every year and by passing an annual on-line assessment.

The number of FACTS advisers has increased steadily and substantially since 2000, reaching around 3600 throughout the UK in 2018 (Fig 2). FACTS advisers were involved in half of all farms surveyed in England in 2018 (Fig 3).

Fig 2 FACTS advisers with access to the information service

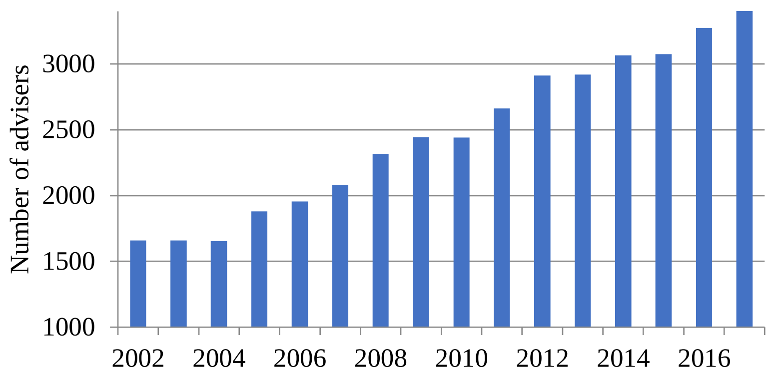
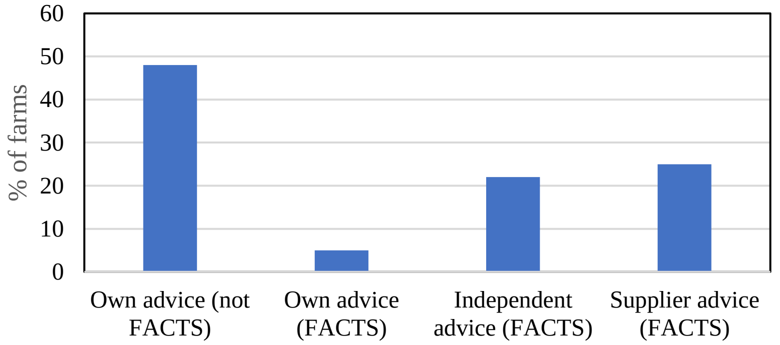


Fig 3 Sources of information for nutrient planning

(Source: Defra Farm Business Survey, 2018)



Feed Advisers Register (FAR): FAR (www.feedadviserregister.org.uk) was established in 2013 by AIC and the feed sector as a commitment to improve efficiencies in animal feeding practices and to reduce nutrient emissions. There are now 1091 members involved in demonstrating key competencies necessary to remain on the Register. Initially the competences were designed around whole farm feed planning and links to animal health and fertility – important for greenhouse gas reduction. Further competences have been developed on environmental policy and practical ways to mitigate emissions on farm. FAR advisers must renew their membership annually.

Catchment Sensitive Farming (CSF): CSF is a joint initiative of the Environment Agency and Natural England established in 2006 and funded by Defra and the Rural Development Programme for England. Free advice and training are provided to farmers in selected areas of England that have a high priority for water quality. This advice includes workshops, farm events and individual farm appraisals. Capital grants are offered, at up to 60% of the total funding, to deliver improvements in farm infrastructure. CSF also works with national partners to run joint events and share best practice:

- The Agriculture and Horticulture Development Board
- Professional Nutrient Management Group

- The Rivers Trust
- The Voluntary Initiative
- Soil and Water Management Centre events
- Innovation for Agriculture
- Campaign for the Farmed Environment (CFE)

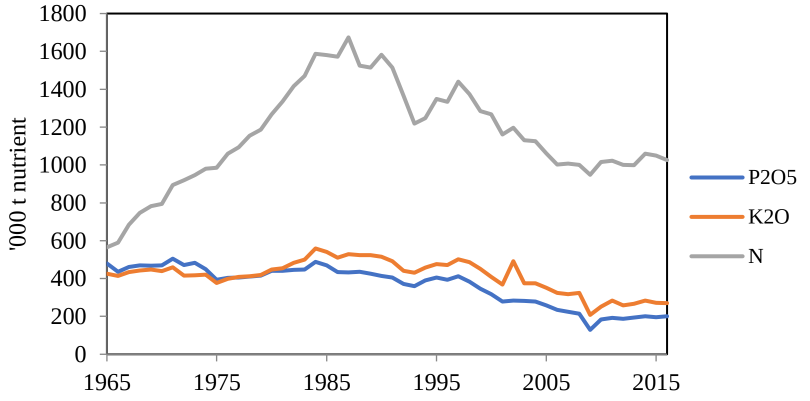
In addition, around 100 local Catchment-Based Approach (CaBA) partnerships have been established. More than 1500 organisations are engaged with CaBA nationwide including NGOs, Water Companies, Local Authorities, Government Agencies, Landowners, Angling Clubs, Farmer Representative Bodies, academia and local businesses. Since CSF was established, advice has been provided to 20,000 farms covering 2.6 million hectares. As a result, farmer have invested £182 million in infrastructure and taken more than 100,000 positive actions to prevent water pollution. For every £1 invested by government, CaBA partnerships have raised £8.63 from non-governmental funders (CaBA 2017).

4. Nutrient management practices

4.1 Overall use of nitrogen, phosphate and potash in manufactured fertilisers

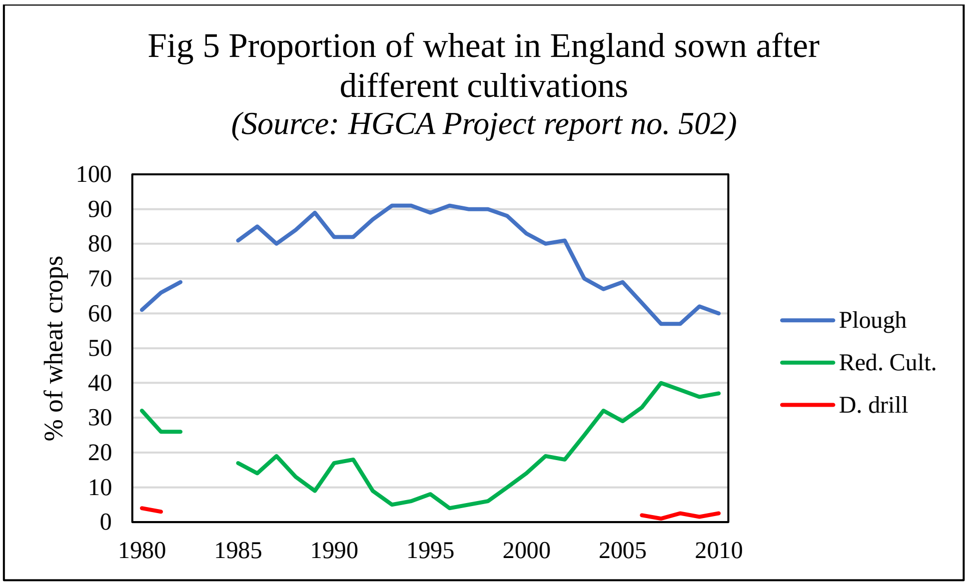
Use of fertilisers in the UK peaked in the mid-1980s, decreased fairly steadily until around 2005 since when it has stabilized (AIC 2018) (Fig 4). Use of fertiliser nitrogen in 2016 was 65% of that in 1984. Much of this decrease occurred on grassland. Use of fertiliser phosphate and potash also has decreased substantially. The fertiliser phosphate now applied is 40% of that applied in 1971 and fertiliser phosphate now applied is less than half that in 1984.

Fig 4 Fertilizer N, P_2O_5 and K_2O used in UK
(Source: AIC statistics)



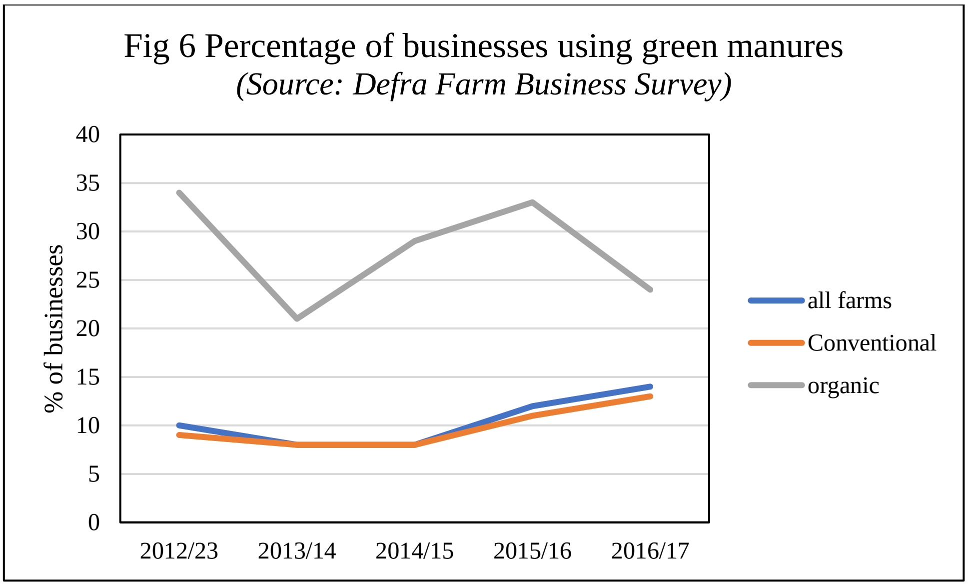
4.2 Trends in soil cultivation and management

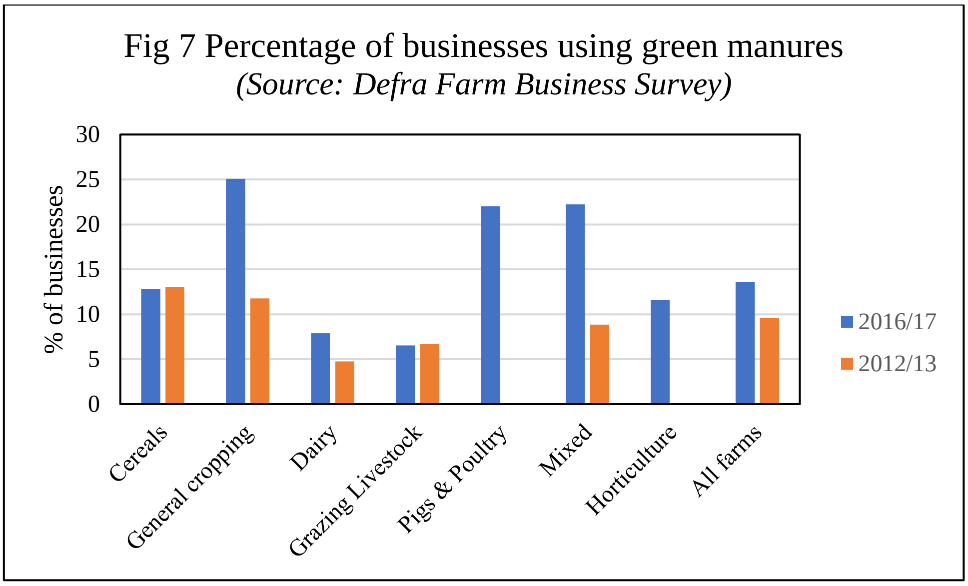
The popularity of non-inversion tillage (min-till, minimum cultivation, reduced cultivation, conservation tillage) has varied since 1980. After strong uptake in the 1970s, non-inversion tillage lost popularity during the 1990s (partly due to the ban on straw burning) only to revive again after 2000 (Fig 5). Direct drilling with no cultivation has remained a minor technique for fewer than 5% of wheat crops (AHDB 2012). There appear to be no national statistics on uptake of different cultivation techniques since 2010.



Non-inversion tillage offers savings in cultivation costs but can restrict crop yield at least in the short-term.

Green manures are grown to maintain and build soil structure and fertility. They might have other uses such as weed control and there can be confusion between 'green manures' 'cover crops' and 'catch crops'. In recent years, Defra's Farm Business Survey has included the question 'do you use green manures in your arable rotation?'. Mixed and general cropping farms were more likely to use green manures than were other farm types (Fig 7) but the largest difference was between organic and conventional farms. There was a hint of increased use in conventional farms after 2014 but organic farms remained much more likely to use green manures (Fig 6). The apparent fluctuations in use in organic farms probably is due to the relatively small number of these farms surveyed.





4.3 Use of soil test results

Since the Farming Rules for Water were introduced in April 2018 (Defra 2018a), regular soil testing for phosphorus, potassium, magnesium and pH at five-year intervals has been a legal requirement in England (Defra 2018). In Northern Ireland, soil testing for phosphorus every four years is a legal requirement under the Phosphorus Regulations (Daera 2018). Soil testing for nutrients is not a legal requirement in the rest of the UK although it is strongly recommended by Scottish Quality Crops and the Scottish Government.

The new requirement for soil testing in Farming Rules for Water will affect mainly smaller farms and beef and sheep farms in England. Regular soil testing was already common practice among larger arable farms (Table 3).

Table 3 Regular testing for nutrient content of soil in England
(before introduction of Farming Rules for Water)

Farm	Percentage of farms	Percentage of agricultural area
Small	61	75
Medium	75	76
Large	87	91
Cereals	90	96
Other crops	92	97
Pigs and poultry	54	86
Dairy	80	87
Grazing (LFA)	37	50
Grazing (lowland)	46	63
Mixed	81	88
All farms	69	83

Source: Defra Farm Practices Survey, 2018

Legislation and strong recommendations should bring the amount of UK soil testing done to maximum potential levels within five years at most. However, there is an indication that the results of soil testing could be better used. PAAG data show appreciable percentages of very high and very low P and K indices in arable and grassland samples (Table 4).

Table 4 Percentage of samples in soil indices

(Source: PAAG 2017 report)

P	**0**	**1**	**2**	**3**	**4**	**5**	**>5**
Arable	5	17	29	30	13	4	2
Grass	11	23	31	26	8	2	0

Percentage of samples in class:

K	**0**	**1**	**2-**	**2+**	**3**	**4**	**5**	**>5**
Arable	3	26	31	19	17	3	1	0
Grass	8	35	26	14	12	3	1	0

Table 5 shows the percentages of soil samples in different P and K indices (PAAG 2017). Only 9% of samples analysed were at target index for both P and K. This percentage has remained at 9 or 10% since the first PAAG report in 2009.

Table 5 Percentages of all samples in P and K Indices

(Source: PAAG 2017 report)

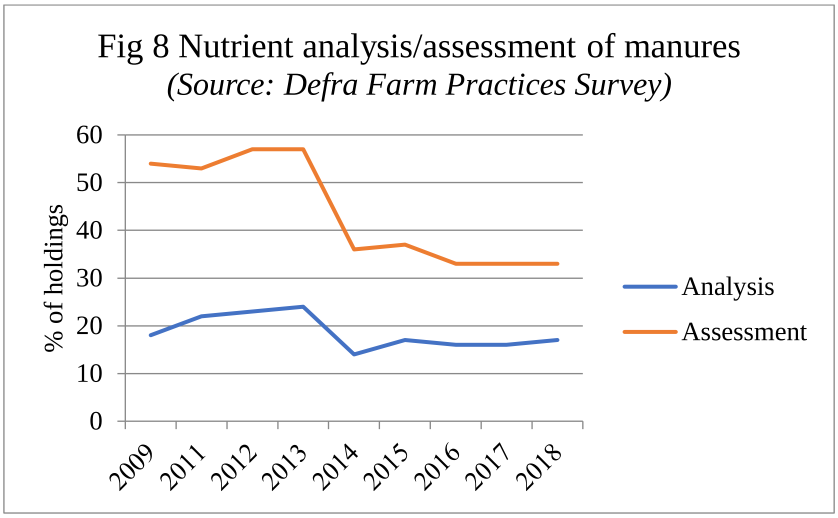
	P index			
K index	<target	target	>target	
<target	12	10	10	32
target	8	9	12	29
>target	7	11	21	39
	27	30	43	100

Routine soil samples include pH as well as P, K and Mg indices. Samples also are taken for pH only. Despite this, lime use nationally is not adequate to replace losses from soil (section 4.8 below) and is decreasing.

The main problem in soil testing now seems not to be the number of samples taken but the use that is made of analytical results.

4.4 Accounting for nutrients in manures

The first step in taking account of nutrients in manures is to estimate their concentration either by laboratory analysis or by assessment using standard tables. Trends in numbers of farms in England reporting either of these methods show a sharp reduction in 2014 (Fig 8). This reduction coincided with a change in the question asked in the Farm Practices Survey. Up to 2013, the questions asked were ‘Do you test (by taking samples) the nutrient content of manure?’ and ‘Do you assess/calculate the nutrient content of manure?’ with options ‘yes’, ‘no’ or ‘not applicable’. From 2014, the single question asked was ‘Do you test/assess/calculate the nutrient content of manure?’ with options ‘Yes, by sampling and lab analysis’, ‘Yes, by sampling and on-farm testing’, ‘Yes, based on published tables’ and ‘No, Not applicable’. The analysis trend shown in Fig 8 combines sampling and lab analysis and sampling and on-farm analysis from 2014. Two main points arising from the trends are the large scope for extending manure assessment and analysis for nutrients (whatever the effects of the change in questions) and the care that must be taken when interpreting survey responses.



Small and grazing livestock farms were the least likely to assess nutrient contents of manures by assessment or analysis. These farms also were least likely to have a manure management plan (Table 6).

Table 6 Uptake of manure management planning in 2018
(% of all holdings)

	Nutrient analysis of manures	Nutrient assessment of manures	Have manure management plan
Small	12	29	51
Medium	15	40	75
Large	28	41	85
Cereals	30	44	69
Other crops	31	42	71
Pigs and poultry	25	27	49
Dairy	21	41	91
Grazing (LFA)	4	15	47
Grazing (lowland)	5	28	53
Mixed	20	47	72
All farms	17	33	63

Source: Farm Practices Survey 2018 based on holdings for which the question was applicable

The British Survey of Fertiliser Practice includes tables showing average field rates of nutrient application for fields where manures were applied and for those where no manure was applied. For a given crop, the difference between these rates is some indication of the adjustments made to fertilizer use where manure is applied. Typical application rates (BSFP) of 24 t cattle or pig FYM/ha or of 30 m^3 cattle or pig slurry/ha will supply around 10-30 kg crop available N/ha, 40-140 kg total P_2O_5/ha and 70-190 kg total K_2O/ha. The Survey does not specify which type of manure was used but these are the amounts that might be used to adjust fertilizer applications. In most cases where manures are applied, no other applied potash would be needed. The Survey data show adjustments to fertilizer nitrogen rates that are reasonably consistent with the likely amount applied in manures, around 20 kg N/ha (Fig 9). However, adjustments to fertilizer phosphate and, especially, potash also were around 20 kg/ha and smaller than the amounts likely to have been applied in manures (Figs 10, 11). Information in the diagrams must be treated with caution as the fields were not paired and, if no phosphate for example had been applied, no adjustment was possible. Nevertheless, the apparent adjustments to phosphate and potash use seem smaller than those that could be achieved and there is no evidence for an improving trend.

Fig 9 Adjustment to N rate for manure use
(Source: BSFP)

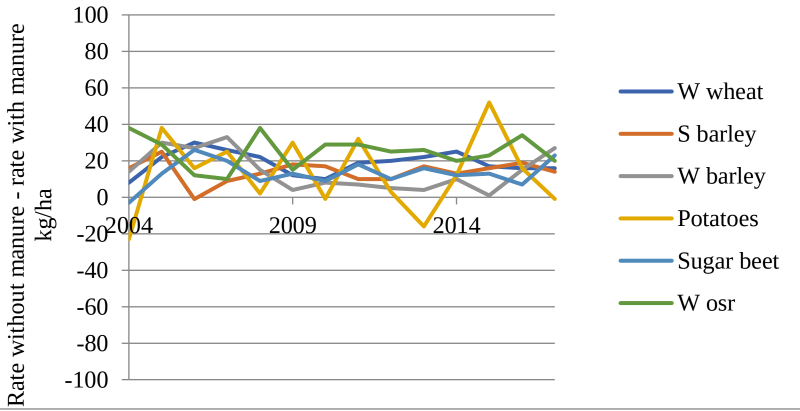


Fig 10 Adjustment to P_2O_5 rate for manure use
(Source: BSFP)

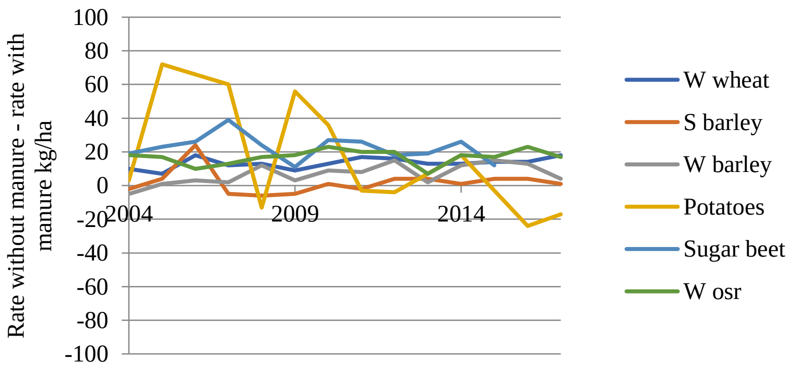
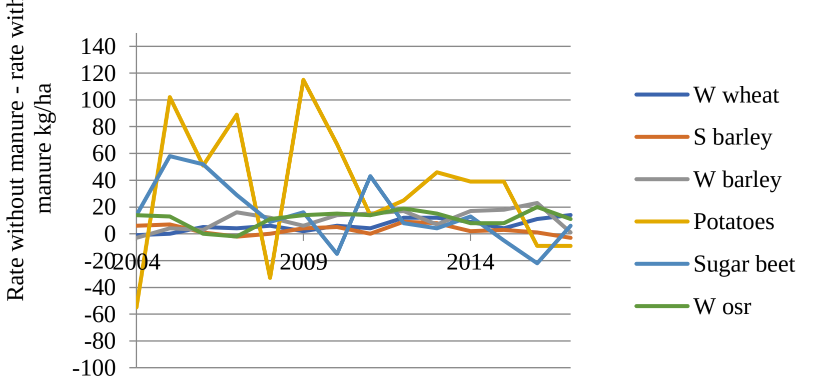


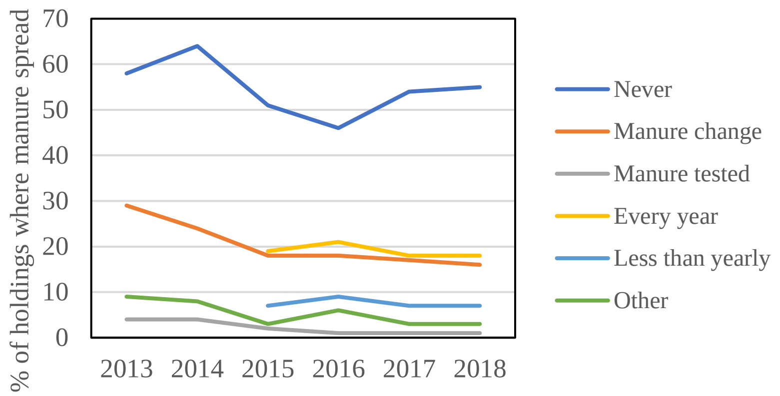
Fig 11 Adjustment to K_2O rate for manure use
(Source: BSFP)



4.5 Spreading manures

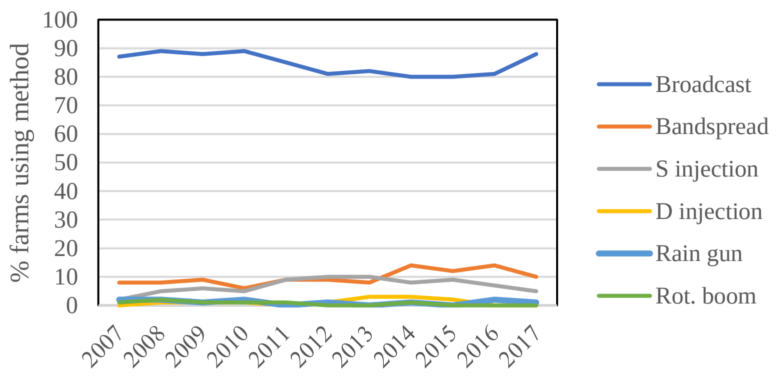
Manures need to be spread as accurately as possible, at the intended rate and evenly. The Farm Practices Survey since 2013 has included a question about the calibration of manure spreaders for rate and setting. Because it is known that farmers may interpret this as testing evenness of spread, there is some uncertainty therefore about the meaning of the results but in any event around half of farmers who spread manure reported never calibrating their spreaders (Fig 12). Around 30% of farms reported calibrating spreaders annually or whenever manure type changed as normally would be recommended.

Fig 12 Calibration of manure spreaders
(Source: Defra Farm Practices Survey)



From 2007, the British Survey of Fertiliser Practice has shown 80-90% of farms to be broadcast spreading slurry and around 10% band spreading (Fig 13). However, the survey also shows 20% of cattle slurry being spread by contractors who are more likely than farmers to use band or injection spreading.

Fig 13 Slurry application method
(Source: BSFP)



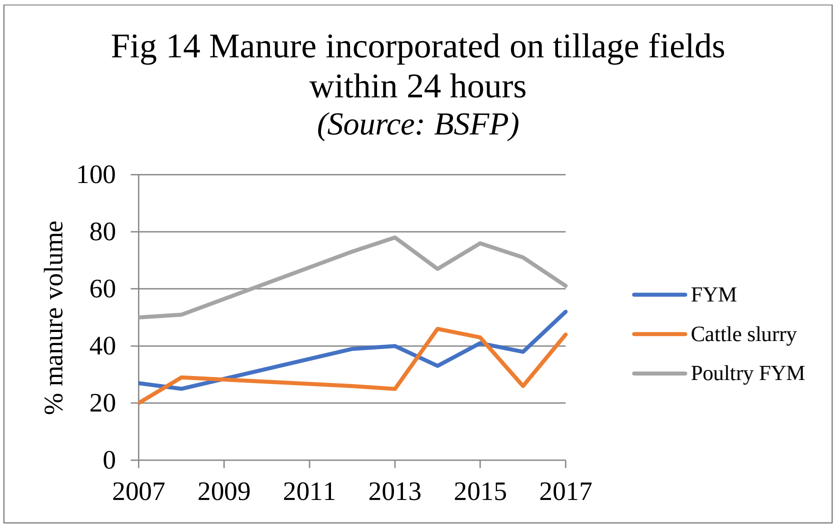
Where manure is broadcast spread, rapid incorporation is necessary to minimize emission of ammonia. When manure is left on the soil surface, a large proportion of ammonia loss can occur within six hours. There are various recommended periods and one legally-binding period between application and incorporation in the UK:

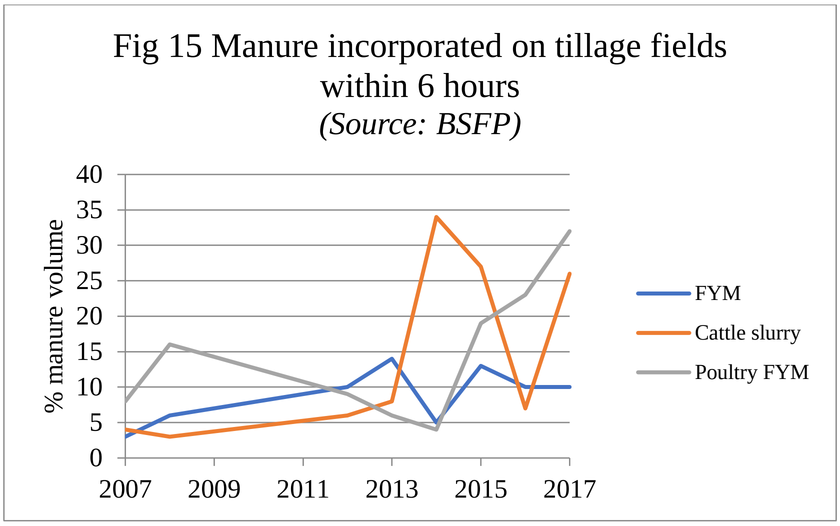
Document	Incorporation on arable land:
Protecting Our Water, Soil and Air (England) and PEPFAA (Scotland)	within 6 hours (slurry), 24 hours (solid manures)
NVZ guidance (England)	within 24 hours (FYM if within 50m of water and land slopes, poultry, slurry)
NAP and Phosphorus Regulations guidance (Northern Ireland)	solid manures: low risk <3 days, moderate risk 4-5 days, high risk >5 days
	slurry: low risk <12 hours, moderate risk 12-48 hours, high risk >48 hours
COGAP for Reducing Ammonia Emissions (England)	within 12 hours

The only legal requirement is for incorporation within 24 hours of application in NVZs in England.

Data from the British Survey of Fertiliser Practice indicate a rising trend in the volume of manures incorporated within 24 or 6 hours of application (Figs 14, 15). Some of the cattle slurry will have been applied to autumn-sown crops in spring so necessarily will not be incorporated.

Rationalisation of the required intervals between application and incorporation shown above would help in promoting rapid incorporation.



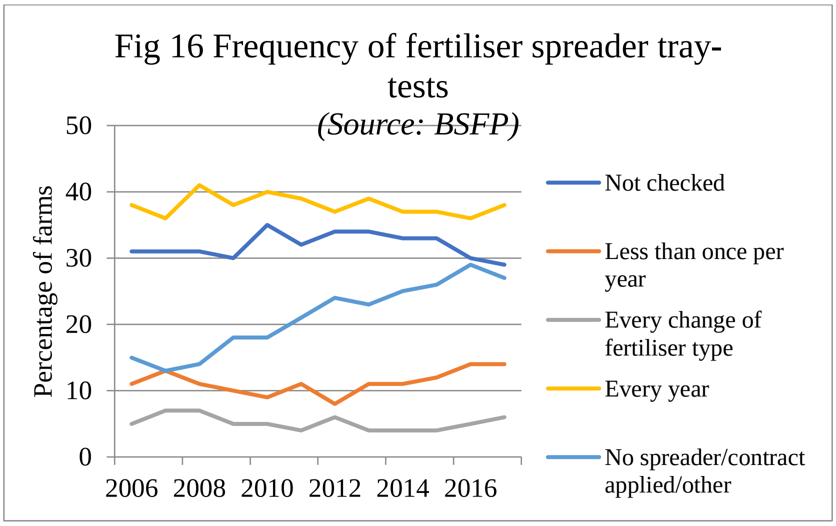


4.6 Applying manufactured fertilisers

With a maximum claimed bout width now greater than 50m and with 36m common in practice, there is a pressing need to ensure evenness of application. This depends on regular, at least annual, tray-testing of spreaders or use of the latest spreader or sprayer technology.

Farm assurance scheme standards include requirements for fertiliser spreaders. Red Tractor (2017) standards with 78,000 compliant farms, specifies 'manufactured fertiliser application equipment is calibrated at least annually' but there is no explicit requirement for testing of spread pattern (using tray tests). 'Calibration' usually is taken to mean checking for correct rate of application. Scottish Quality Crops (SCP 2017) specifies 'Fertiliser spreaders must be adequately maintained and calibrated. Annual calibration checks and maintenance must be recorded for each product' and advises tray-testing but with no interval stated. Compliance with assurance schemes therefore cannot be relied on to ensure tray-testing of fertiliser spreaders. Details on calibrated and testing fluid fertilisers applications may be more reliable.

The British Survey of Fertiliser Practice has provided annual information on tray-testing from 2006 since when the percentage of farms reporting annual tray-testing has remained at 35-40%. The Farm Practices Survey for 2012 gave a corresponding value of 50%. Around 30% of farms reported never checking spread pattern and a further 10% tray-tested less frequently than annually (Fig 16). There has been some growth in professional testing of fertilizer spreaders. SCS (Spreader and Sprayer Testing Ltd) now conduct around 3000 tray tests on fertilizer spreaders annually but in 1999 tested fewer than 300 (SCS 2018).



Development in spreader technology, where sensor-controlled flow rate is now common, has reduced the need for manual spreader calibration for application rate. The same might happen for spread pattern management. Kuhn/Rauch and Amazone have introduced radar-sensing of spread pattern and if this technology spreads there could be reduced need for tray-testing. In the meantime, there seems scope for improvement in spreader testing and setting.

The National Sprayer Testing Scheme (NSTS 2018) was extended in 2015 to cover fertiliser spreaders. Spreaders are tested to a common national protocol.

4.7 Application of sulphur

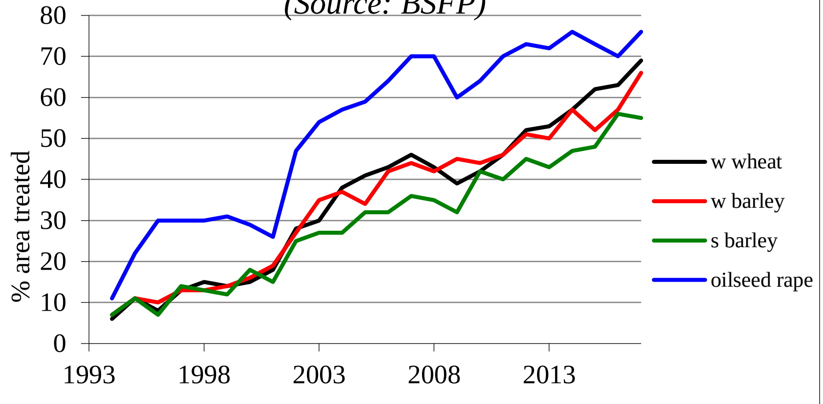
UK emission of sulphur dioxide has decreased from 6.5 million tonnes SO_2 in 1979 to 180,000 tonnes in 2016. This has resulted in greatly reduced deposition of sulphur on agricultural land and a consequent increase in requirement for applied sulphur.

In 2010, the 10th edition of RB209 included recommendations for sulphur application, in potentially responsive conditions, to cereals, oilseed rape, peas, brassica vegetables and grass cut for silage. For the current, 9th edition, (AHDB 2017), sulphur recommendations were extended to grazed grass, sugar beet, potatoes, whole crop cereals, and fodder crops apart from maize. This increasing recognition of the need for sulphur application is reflected in usage of sulphur fertilisers. AIC statistics show consumption of sulphur in fertilisers increased from a negligible level in 1995 to around 65,000 t SO_3 in 2002 and to 200,000 t SO_3 in 2016 (AIC 2018).

In 1994, fertiliser sulphur was applied to around 10% of the cereal and oilseed rape area in Great Britain. In 2016/17, this had changed to 80% of the oilseed rape area and 55-70% of the cereal area (Fig 17). After many years of low usage, application of fertilizer sulphur to grassland also has increased in recent years (Fig 18).

Fig 17 Sulphur dressing cover for arable crops

(Source: BSFP)



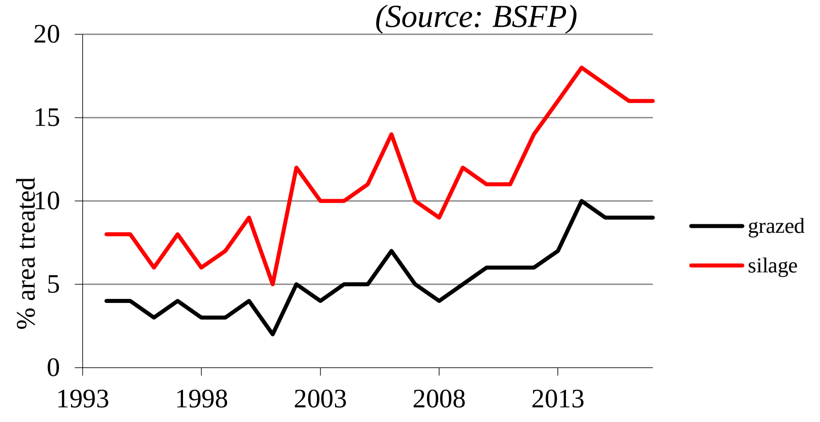


Fig 18 Sulphur dressing cover for grassland
(Source: BSFP)

The ratio of fertilizer nitrogen to sulphur (SO_3) in both arable crops and grassland seems to be converging at around 3/1 (Figs 19 and 20) equivalent to a N/S ratio of 7/1.

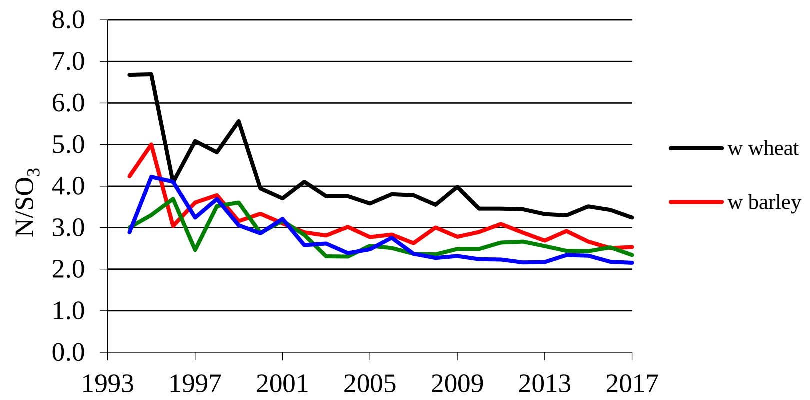


Fig 19 Fertilizer N /SO_3 ratio tillage crops
(Source: BSFP)

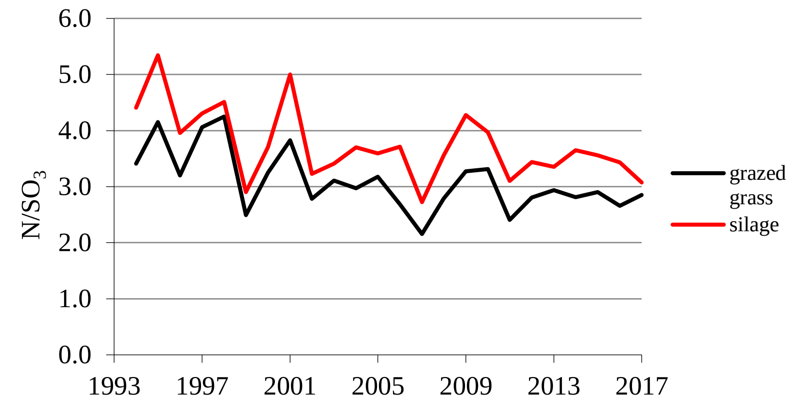


Fig 20 Fertilizer N/SO_3 ratio grassland
(Source: BSFP)

Overall, the trend in usage of sulphur fertilisers is encouraging, especially for the main arable crops. There might be scope for greater fertiliser sulphur application to grassland. The usage trend on grass is positive but the proportion of area treated remains low compared to that in cereals and oilseed rape. Partly this will be due to use of cattle slurry and FYM on grassland. The Nutrient Management Guide (RB209) includes availability values for sulphur in organic manures. Using these values, spring application of cattle FYM at 35 t/ha would supply 13 kg available SO_3/ha. Application of cattle slurry at 30 m^3/ha in spring would supply around 7 kg available SO_3/ha. In responsive conditions, these amounts would not provide sufficient available sulphur to meet grass needs over the season. There does appear a need therefore to increase the use of fertiliser sulphur on grassland.

4.8 Application of lime

The percentage of area to which lime was applied differed between tillage crops and grassland (Fig 21) and, for tillage crops, between England/Wales and Scotland. In recent years, 5-7% of tillage land in England/Wales but 12-20% in Scotland had been limed. Where lime was applied, the average rate of application to tillage crops has decreased from around 5 t/ha in 2003 to just less than 4 t/ha in 2017 (Fig 22).

The average liming intervals of around thirteen years in tillage crops in Great Britain and thirty-three years in grassland appear inadequate to maintain soil pH in the long term. In the PAAG report for 2016/17 soil pH was lower than 6.0 in 16% of arable samples and lower than 5.5 in 18% of grassland samples.

Fig 21 Percentage area treated
(Source: BSFP)

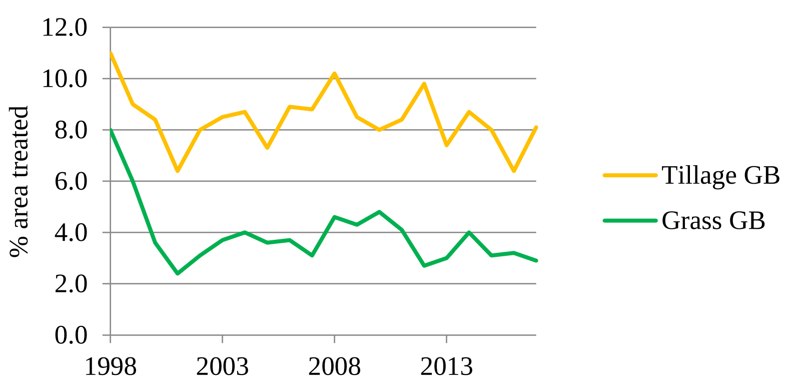
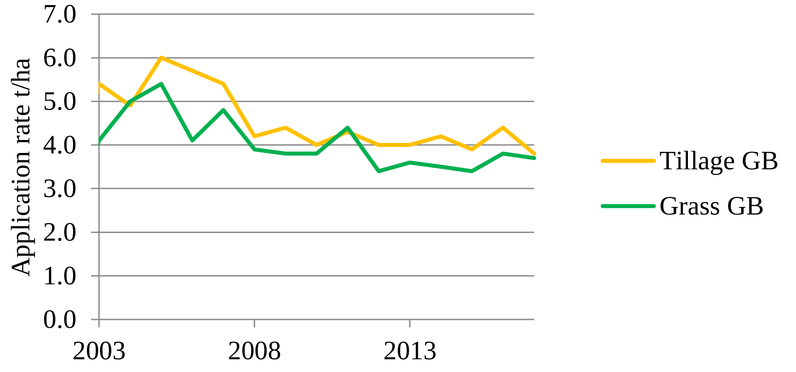
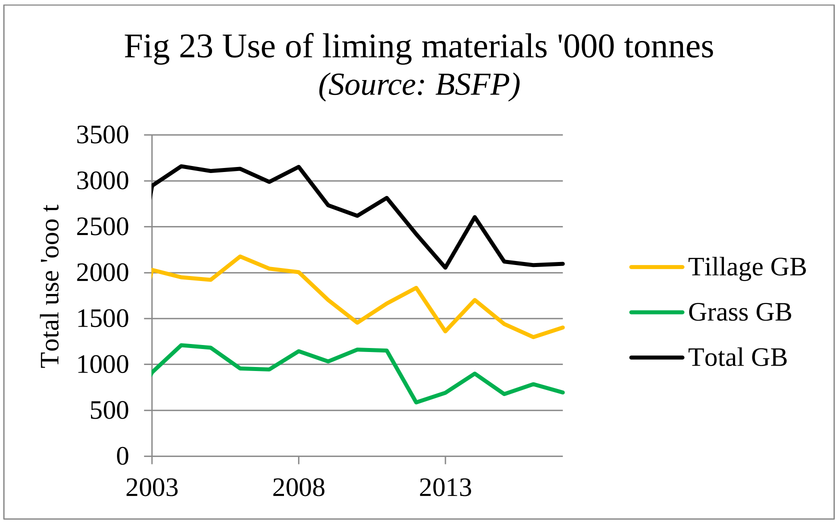


Fig 22 Average application rate t/ha
(Source: BSFP)



Use of liming materials in Great Britain has decreased over the past two decades at an average rate of around 86,000 tonnes/year. The total amount of lime applied was calculated using data from the British Survey of Fertiliser Practice (Fig 23). Total amount does not take account of the different effectiveness of various liming materials so is a crude measure. However, the downward trend seems clear. The amount of lime applied in 2016/17 was around half of the estimated annual loss of 4.25 million tonnes $CaCO_3$ estimated for UK soils (Goulding 2016).

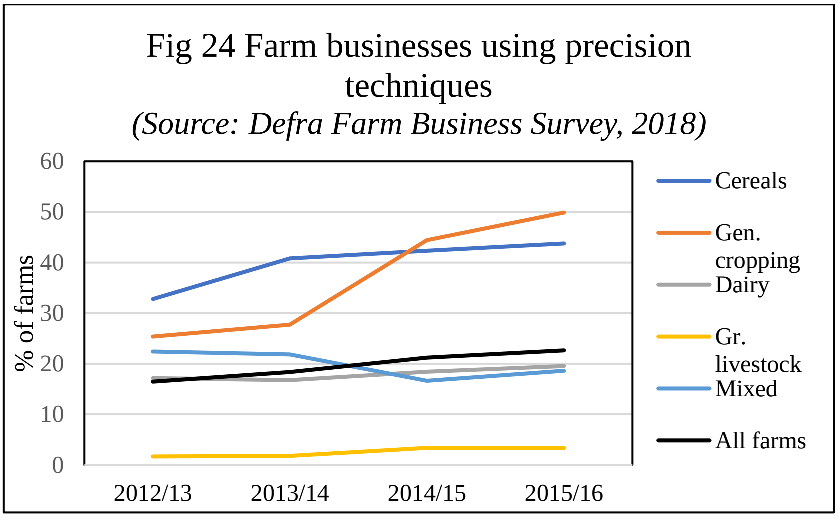


4.9 Variable within-field application

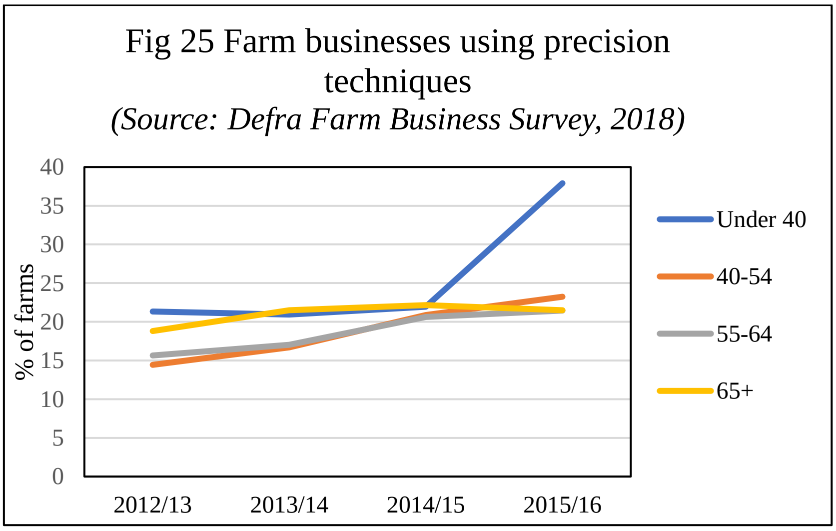
Soil properties relevant to nutrient supply vary spatially within as well as between fields. Applying nutrients within the field to match soil variation should be beneficial either in reducing total nutrient use or in increasing overall crop yield. There is a cost for equipment and control systems but net benefits have been estimated for variable nutrient application (AHDB 2009, 2016a, 2016b).

There are several ways to achieve variable within-field application from zoning of the field into several relatively uniform parts to continuous real-time control of application rate. A number of technologies can be involved: soil scanning, yield mapping, soil mapping for P and K, GPS positioning with or without RTK correction, canopy sensing and spreader control systems. All of these receive a deal of press coverage and the general impression is that uptake of various elements of precision farming is increasing. Statistics to test this impression are rather sparse.

In recent years, the Farm Business Survey published by Defra has included a question on precision farming: 'do you carry out precision farming techniques, i.e. soil mapping and the use of satellite technology to guide fertiliser applications?' (Defra 2018b). The 'i.e.' *sic* really should have been 'e.g.' but respondents probably understood the gist of the question. Results showed clear differences among farm types (Fig 24). Uptake of nutrient-related precision farming was much greater among cereals (two thirds of output from combinable crops) and general cropping (two thirds of output from arable crops but excluding cereals farms) farms than it was among mixed and grassland farms. Results also supported the impression of increasing uptake of precision farming techniques, relatively quickly among mixed cropping farms, more slowly among mixed and grassland farms.



Survey results also showed a sharp increase in uptake of precision farming in younger farmers (<40 years) between 2014/15 and 2015/16 (Fig 25). The next survey should show whether this is a real trend or an anomaly.

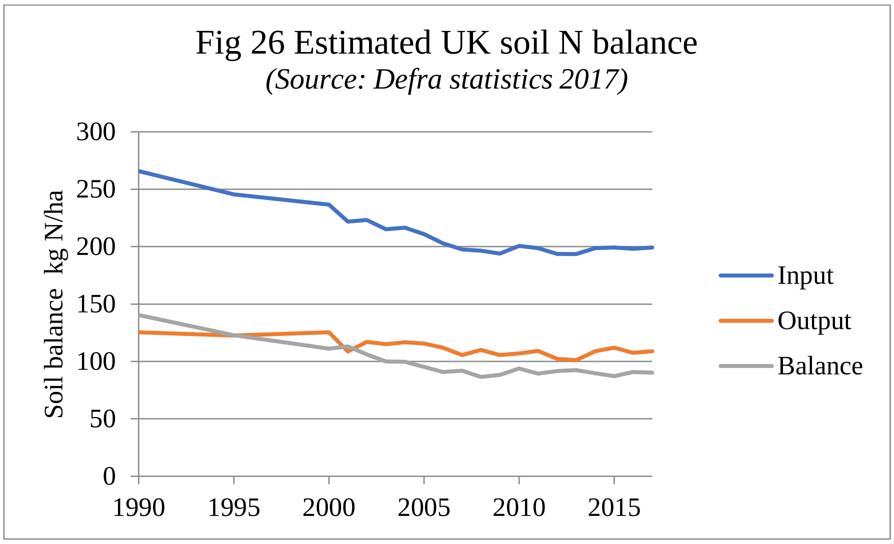


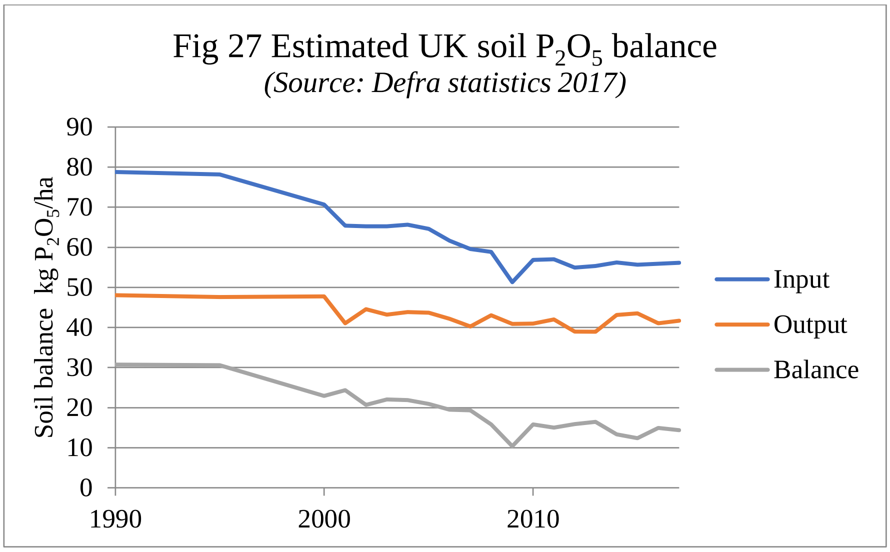
Technologies used for variable within-field nutrient application are developing and diversifying rapidly. Early entrants were Yara's N-Sensor and the soil P and K mapping by SOYL and others. Now there are ongoing changes in interconnectivity and autonomy of farm machinery, UAVs, soil sensors, spread pattern monitoring and software support that should make nutrient application very different in a few years, at least on larger farms.

5. Soil nitrogen and phosphate balances

Defra (2018c) has published a series of statistical reports on soil N and P balances for the UK and England. Unlike farm nutrient balances, soil balances include the recycling of nutrients in manures produced and used on the farm. The inputs are manures, mineral fertilisers, atmospheric deposition and biological fixation. The removals are crop production and herbage/fodder production for livestock, including grazing. Every nutrient input or removal is either estimated directly (atmospheric deposition) or calculated by applying a coefficient (for example, for the amount of nitrogen that a dairy cow produces each year) to the corresponding physical data (for example, number of dairy cows).

Provisional estimates for 2017 show the nitrogen balance to be a surplus of 90 kg N/ha of managed agricultural land, a reduction of 21 kg N/ha (-19%) since 2000 and the phosphate balance (converted from phosphorus in the Defra report) to be a surplus of 14 kg P_2O_5/ha, a reduction of 9 kg P_2O_5/ha (-38%) since 2000 (Figs 26, 27).





6. Nitrogen use efficiency

6.1 Method of calculation

In this report, nitrogen use efficiency (apparent NUE but for brevity called NUE here) for arable crops is the ratio of crop yield (kg/ha) to input of manufactured fertilizer nitrogen (kg N/ha). NUE values calculated in this way must be interpreted with care (see below) but this method was the only one that could be applied to available national data. For grassland, the population of grazing livestock expressed as livestock units was used as a measure of production, again because this was what available data allowed. These are the same as the methods of calculation described in the 2012 and 2015 reports.

6.2 Arable crops

UK average yield data were available from Defra statistics for four main arable crops: wheat, oilseed rape, maincrop potatoes and sugar beet (Fig 28). Overall nitrogen application rates for GB (England, Scotland and Wales) were available from The British Survey of Fertiliser Practice (Fig 29). The discrepancy between UK and GB was unlikely to have affected calculated trends significantly (for sugar beet, not at all). Calculated NUE is shown in Fig 30. Yield, nitrogen application rate and NUE data were normalized so that the 1994 value for each crop = 100.

Over the period 1994 to 2017, NUE for wheat remained roughly stable. There were some increases in oilseed rape and potatoes and a very large increase in sugar beet.

Care is needed in interpreting these trends as there are three factors that can influence NUE calculated in this way:

a) Application rate of nitrogen: as 40-50% of crop yield typically is supported by non-fertilizer nitrogen supply, NUE calculated as the ratio of yield to the rate of nitrogen applied, will tend to increase as nitrogen rate decreases. If no fertilizer nitrogen is applied, there will still be a substantial crop yield so NUE will be infinitely high.
b) Changes in crop yield due to practices that are not related to crop nutrition, for example variety improvement or changes in pest and disease control.
c) Changes in nutrient management practices.

There is evidence that all three of these factors operated during the period 1995 to 2013. Trends in yield showed a large increase for sugar beet but much smaller increases for the other crops, especially wheat (Fig 28). Overall nitrogen application rates were quite stable for wheat and oilseed rape but decreased significantly for potatoes and, especially, for sugar beet (Fig 29). Trends for the four crops can be summarized:

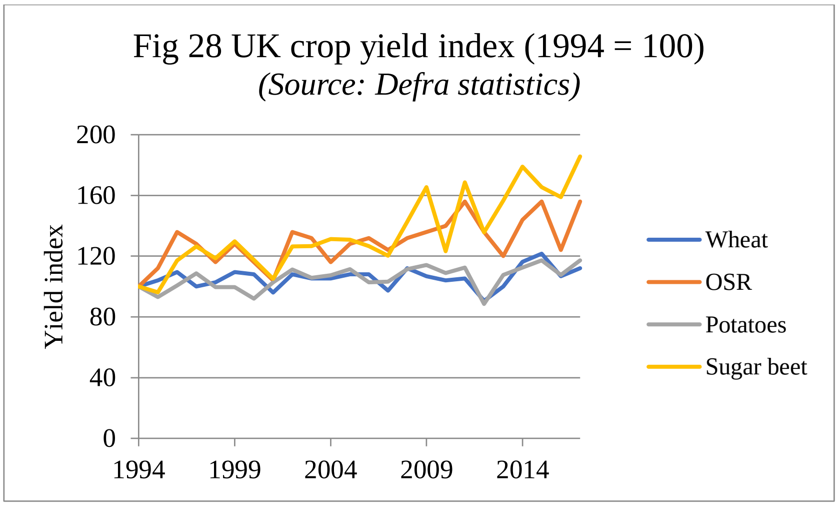
Wheat: no significant changes in yield, nitrogen rate or NUE.

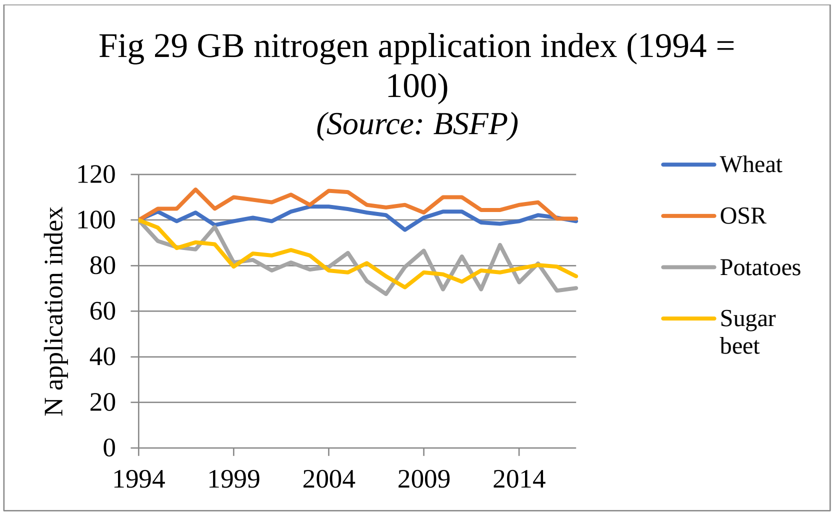
Oilseed rape: No significant change in nitrogen rate, small increases in yield and NUE.

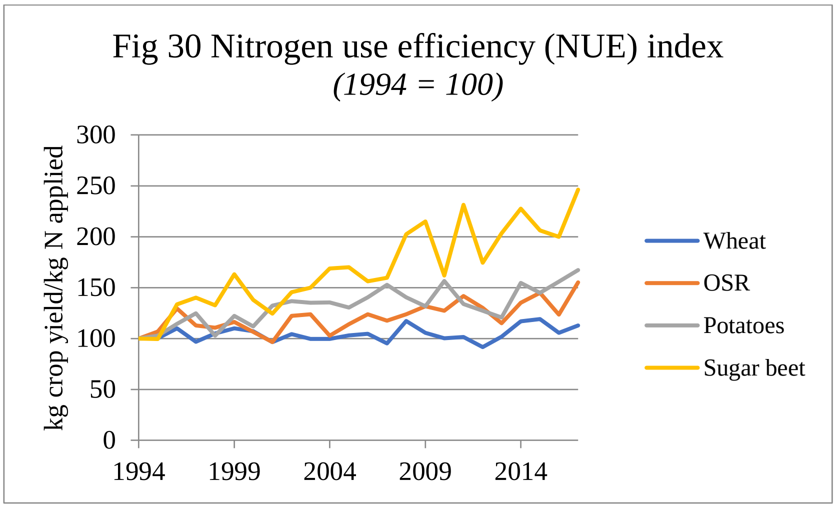
Maincrop potatoes: Small increase in yield, reduction in nitrogen rate and increase in NUE.

Sugar beet: Large increase in yield, large decrease in nitrogen rate and very large increase in NUE.

Sugar beet has seen an increase in NUE simultaneous to an increase in yield. In this crop there have been real technical improvements in agronomic practices and/or variety development. The same applies, to a lesser extent, in oilseed rape. The increase in NUE in potatoes could be due to a decrease in nitrogen application without any other changes. The situation in wheat is disappointing with apparent stagnation in yield, nitrogen use and NUE.



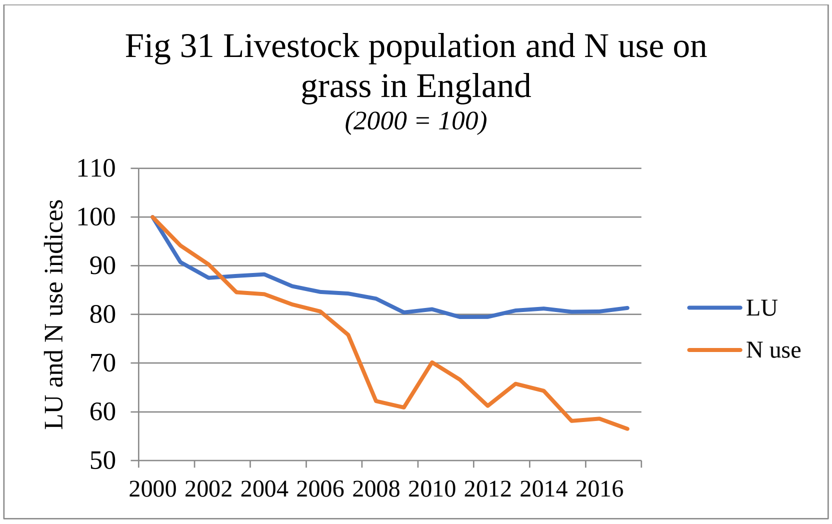


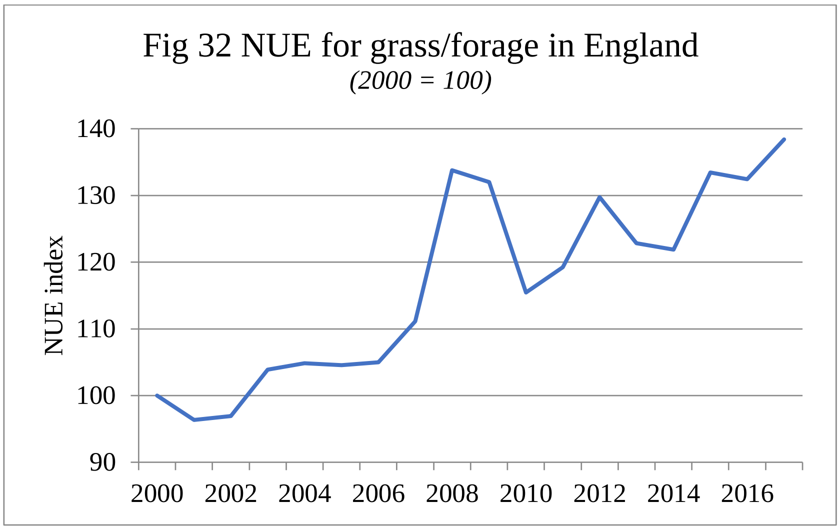


6.3 Grassland

A different approach was needed for grassland to take account of the data that were available. NUE for grassland is defined here as the ratio of total grazing livestock (cattle + sheep) population expressed as livestock units (LU) to input of manufactured fertilizer nitrogen (kg N). Data used for nitrogen input were application rates (kg N/ha) from the British Survey of Fertilizer Practice and grassland area from Defra statistics (all grass minus rough grazing). In order to minimize the effect of sheep maintained on uplands to which fertilizer was not applied, NUE was calculated for England rather than GB or UK. Grass area data for England were available from Defra statistics and nitrogen rates for England/Wales were available from the British Survey of Fertiliser Practice. Details of the method of calculation are in Appendix 2.

Calculated in this way, NUE has increased by around 40% since 2000 (Fig 32). As with arable crops, changes in NUE could be due to those in nitrogen input or in agronomic practices. Total grazing livestock population in England decreased from 2000 but there was a proportionally greater decrease in nitrogen use on grass (Fig 31). Overall, the data indicate a substantial increase in grassland NUE since 2000 probably due to extensification rather than to improvements in nutrient management practices.





7. Closing the gap to good practice

Trends in nutrient management planning and practices show several instances of ongoing change (usually in the right direction) but others of stubborn stability despite strong advisory pressure. Success stories include:

- Expansion in industry-supported advisory schemes: FACTS and FAR
- Advisory impact of CSF
- Increases in NUE in grassland, sugar beet, oilseed rape and potatoes
- Application of sulphur to correct deficiency in arable crops
- Development and uptake of precision farming techniques

Areas where change is desirable include:

- Making use of soil testing for nutrients and pH: The number of soil samples taken is no longer an issue. Movement is needed in the main indicators for the use of test results with convergence of soil indices on target values and an increase in the amount of lime applied.

- Analysis/assessment of manures: Survey data indicate scope for much greater use of standard tables for manure nutrient assessment (after all, these are free) and laboratory analysis.

- Adjusting fertiliser use for manures: There seems a need to ensure nutrients applied in manures are taken fully into account when deciding on fertiliser use. This applies particularly to phosphate and potash.

- Calibration of manure spreaders: Manure nutrients cannot be used effectively if the rate of application is uncertain. Reluctance to calibrate a manure spreader is understandable given the material involved but this needs to be overcome.

- Applying sulphur to grass: The area of silage grass receiving fertiliser sulphur is increasing but it remains smaller than would be expected even allowing for use of manures. Guidance in visual identification of sulphur deficiency and distinguishin it from nitrogen deficiency would be helpful.

- Applying lime: The amount of lime applied is much less than the estimated loss of calcium carbonate from UK soils and is decreasing. The trend in use needs to be reversed.

- NUE in wheat: While NUE (measured as the amount of grain harvested per tonne of fertiliser nitrogen applied) has increased substantially in other crops and grassland, it has remained stable in wheat.

The need for these changes does not apply on all farms. With the possible exception of NUE in wheat, the changes listed above just involve an increase in the proportion of farms implementing best practices. The real gap is between the 'best' farms and the rest and closing it will require both effective advice and the sharing of experience among farms. There are examples of farms that are getting things right in the Tried & Tested (www.nutrientmanagement.org/case-studies) and SWARM (www.swarmhub.co.uk/farmer-profiles/) web sites.

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Appendix 1 Yield and nitrogen rate data used to calculate NUE for arable crops

	Wheat		Oilseed rape		Maincrop potatoes		Sugar beet	
	t/ha	kg N/ha	t/ha	kg N/ha	t/ha	kg N/ha	t/ha	kg N/ha
1994	7.4	186	2.5	179	41.8	194	44.7	122
1995	7.7	193	2.8	188	38.9	176	43.0	118
1996	8.1	185	3.4	188	42.1	171	52.4	107
1997	7.4	192	3.2	203	45.4	169	56.5	110
1998	7.6	182	2.9	188	41.6	188	53.0	109
1999	8.1	185	3.2	197	41.6	158	58.0	97
2000	8.0	188	2.9	195	38.5	160	52.5	104
2001	7.1	185	2.6	193	43.0	151	47.0	103
2002	8.0	193	3.4	199	46.5	158	56.5	106
2003	7.8	197	3.3	191	44.2	152	56.6	103
2004	7.8	197	2.9	202	44.9	154	58.7	95
2005	8.0	195	3.2	201	46.6	166	58.5	94
2006	8.0	192	3.3	191	43.0	142	56.6	99
2007	7.2	190	3.1	189	43.1	131	53.8	92
2008	8.3	178	3.3	191	46.6	154	63.8	86
2009	7.9	188	3.4	185	47.7	168	74.0	94
2010	7.7	193	3.5	197	45.5	135	55.1	93
2011	7.8	193	3.9	197	45.0	163	75.4	89
2012	6.7	184	3.4	187	33.0	135	60.7	95
2013	7.4	183	3.0	187	43.0	173	72.1	94
2014	8.6	185	3.6	191	43.0	141	80.0	96
2015	9.0	190	3.9	193	49.0	157	74.0	98
2016	7.9	188	3.1	180	45.0	134	81.0	97
2017	8.3	185	3.9	180	49.0	136	783.0	92

Appendix 2 Method of calculating grassland NUE

For calculating grassland NUE, conversion from livestock head to LU was:

	LU/head
Total breeding herd	
Dairy herd	1.00
Beef herd	0.60
Aged 2 years or more	
Dairy	0.60
Beef	0.60
Aged 1-2 years	
Dairy	0.30
Beef	0.30
Aged 2 years or more	
Bulls for service	1.00
Females for dairy herd replacement	1.00
Females for beef herd replacement	0.60
Aged 1- 2 years	0.30
Bulls for service	
Females for dairy herd replacement	
Females for beef herd replacement	
Other cattle	
Aged 2 years or more	
Male	0.80
Females intended for slaughter	0.80
Aged 1 - 2 years	
Other male cattle	0.30
Females intended for slaughter	0.30
Under 1 year	0.20
Calves intended for slaughter	
Other male calves (including bull calves intended for service)	
Other female calves	

These values were applied to livestock populations in Defra statistics to derive total LU for England.

Nitrogen use data used for calculating grassland NUE

	Grass area ha	Overall N kg N/ha	N used on grass tonnes N	N used on forage tonnes N	Total N used tonnes N
2000	3639057	95	345710	8000	353710
2001	3612249	90	325102	8000	333102
2002	3663347	85	311384	8000	319384
2003	3685774	79	291176	8000	299176
2004	3760869	77	289587	8000	297587
2005	3919877	72	282231	8000	290231
2006	4015614	69	277077	8000	285077
2007	4064898	64	260153	8000	268153
2008	4076549	52	211981	8000	219981
2009	3839174	54	207315	8000	215315
2010	3875056	62	240253	8000	248253
2011	3858799	59	227669	8000	235669
2012	3863730	55	212505	8000	220505
2013	3940892	59	224631	8000	232631
2014	3923532	58	227565	8000	235565
2015	3877575	53	205511	8000	213511
2016	3909159	53	207185	8000	215185
2017	3918740	51	199856	8000	207856

A constant value was used for nitrogen use on forage crops (maize, root and leafy forage crops) as there were no consistent data for individual crops in Defra statistics and the British Survey of Fertiliser Practice.

LU and nitrogen use data used for calculating grassland NUE

	Total LU	N applied to grass tonnes N
2000	4925682	353710
2001	4470473	333102
2002	4311361	319384
2003	4328992	299176
2004	4346398	297587
2005	4227476	290231
2006	4169094	285077
2007	4150402	268153
2008	4099821	219981
2009	3959885	215315
2010	3992370	248253
2011	3914527	235669
2012	3916215	220505

2013	3980119	232631
2014	3999970	235565