Professional Nutrient Management Group

Update report on nutrient management planning

January 2013

Summary

Recent changes in nutrient management planning and practices were described by comparing latest survey data with those reported in 2009 (Farm Practices Survey) and annually (British Survey of Fertiliser Practice).

Survey data generally showed increases in reported possession of a nutrient management plan and annual updating of the plan. Use of professional advice to help in preparing a plan had changed little except in grazing livestock lowland farms where 84% of farms reported such use in 2012 against 42% in 2009. Regular soil testing continued to be reported by a majority of farms and by more than 90% of mainly arable farms. This apparent development needs further investigation and confirmation if possible.

There were fewer changes in the reported use of manure analysis or assessment of the nutrient content of manures. The launch of MANNER-NPK in early 2013 offers an opportunity to promote greater awareness of the nutrient value of manures. MANNER-NPK could be promoted alongside Think Manures and the new NIRS manure analysis service.

Grazing livestock farms remain lowest in use of planning tools. However, the Tried & Tested plan has made good progress, use being reported by 21% of grazing livestock farms in LFAs in 2012 (3% in 2009) and by 16% in lowland areas (13% in 2009). This success could be reinforced and might be a model for other paper-based planning tools for these farms.

Changes, and the current situation, in nutrient management practices were described using data from the annual British Survey of Fertilizer Practice and from the PAAG report for 2012.

Use of fertilizer phosphate and potash continued to decline and fail to match removals in the main arable crops. While most farms reported regular soil analysis, the results seemed not to be acted on. Only 8-10% of arable and grassland soils were at target indices for both P and K. Soil pH was lower than 6.0 in 20% of arable soil samples analyzed and lower than 5.5 in 23% of grassland samples. The main need seems to be to encourage the better use of soil analytical results and the right corrective action rather than to promote soil testing.

Apparent nitrogen use efficiency (NUE) in arable crops was calculated by dividing yield by fertilizer nitrogen rate. This was the only method suited to the available data but was subject to misinterpretation – reducing fertilizer nitrogen rate without any other changes would result in an increase in NUE and a decrease in yield. An increase in NUE over years due to technical improvements would be demonstrated where NUE increased and crop yield increased or remained unchanged. This was the case in sugar beet and, to a lesser extent, in oilseed rape. NUE increased in maincrop potatoes but due partly or largely to a reduction in fertilizer nitrogen rate. In wheat there were no apparent trends in nitrogen rate, yield or NUE.

NUE was calculated for grassland by dividing the grazing livestock population expressed in livestock units, by the total amount of fertilizer nitrogen applied to grass. This too was subject to misinterpretation for the same reason as for arable crops. Since 1995, NUE increased in grassland but this appeared due largely to extensification rather than to any improvement in agronomic practices.

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1.0 Changes in nutrient management 2009 to 2012

1.1 Method of assessment

Changes were identified by comparing results from the Defra Farm Practices Survey of 2012 with those from the similar survey in 2009. Change in an item was treated as significant where it exceeded the 95% confidence limit on the 2012 value. Significant increases were marked by showing the value in bold. Decreases were shown in bold italic. The survey covered 61,000 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.

1.2 Changes in uptake of nutrient management planning

There were many changes among the components of nutrient management planning, the great majority being increases (Table 1).

Table 1 Components of nutrient management planning in 2012
(% of all holdings, 2009 values in parentheses)

	Have nutrient management plan	Take professional advice for NMP	Annually update NMP	Regular soil testing	Nutrient analysis of manures	Nutrient assessment of manures	Have manure management plan
Small	**55 (42)**	83	70	68	11	39	48
Medium	63	78	**75 (67)**	***65 (75)***	***12 (20)***	***47 (62)***	72
Large	76	81	**78 (72)**	83	33	***69 (74)***	**88 (82)**
Northeast	**59 (40)**	89	68	62	16	44	77
North west	**60 (30)**	**82 (68)**	64	**65 (51)**	19	47	**81 (64)**
Yorkshire	**67 (54)**	74	**73 (62)**	72	26	62	71
East midlands	69	81	78	**84 (76)**	21	64	**68 (61)**
West midlands	**64 (52)**	**83 (68)**	**85 (57)**	71	17	57	74
East	**88 (73)**	85	**83 (74)**	**96 (90)**	**49 (23)**	70	**83 (47)**
South east	**74 (51)**	79	**74 (62)**	**76 (66)**	27	65	67
South west	**62 (39)**	79	**76 (56)**	**69 (61)**	19	52	**77 (67)**
Cereals	**87 (73)**	85	**82 (73)**	96	**33 (19)**	**73 (65)**	**78 (57)**
Other crops	**82 (71)**	***81(91)***	78	93	**44 (22)**	76	**82 (52)**
Pigs and poultry	**75 (20)**	83	**83 (58)**	**76 (33)**	44	63	**75 (53)**
Dairy	**73 (60)**	74	**75 (53)**	80	30	67	90
Grazing (LFA)	**29 (18)**	66	42	32	7	29	**66 (55)**
Grazing (lowland)	**45 (25)**	**84 (42)**	**69 (42)**	**53 (37)**	10	43	**65 (54)**
Mixed	**78 (56)**	78	**77 (58)**	86	***16 (24)***	63	81
All farms	**68** (51)	81 (80)	76 (65)	74 (68)	23 (18)	57 (54)	76 (62)

Source: Farm Practices Survey, 2009, 2012

There was a substantial increase in the percentage of farms surveyed that reported possession of a nutrient management plan. This was especially noticeable for pig and poultry farms and for lowland grazing farms. These farm types also reported increases in use of professional advice for management plans and for regular soil testing. LFA grazing farms tended to lag

behind other farm types in adoption of nutrient management planning and there was little sign of great progress since 2009.

The differences between grazing farms and other types are shown more clearly in diagrammatic form (Fig 1).

1.3 Preparation of nutrient management plans

There have been some changes in the methods used for preparing nutrient management plans. Reported use of PLANET increased substantially in pig and poultry farms and in lowland grazing farms. Tried & Tested made the greatest progress in LFA grazing farms (Table 2). Totals in Table 2 do not add to 100 as there were changes in question options between years: 'created own plan' and 'other' were options in 2009 and 'other' and 'don't know' were options in 2012. As it was not clear how respondents would allocate their answers, these options were excluded in Table 2.

Table 2 Method of creating a nutrient management plan in 2012
(% farms with a plan, 2009 values in parentheses)

	PLANET	Muddy Boots	Tried & Tested	Farmade/ Multicrop
Cereals	29	**22 (15)**	13	17
Other crops	30	25	**20 (8)**	21
Pigs and poultry	**26 (7)**	6	22	**15 (0)**
Dairy	28	12	12	5
Grazing (LFA)	0	22	**21 (3)**	4
Grazing (lowland)	**27 (6)**	**19 (6)**	16	2
Mixed	**32 (18)**	**26 (14)**	**20 (10)**	5
All farms	28 (21)	20 (14)	16 (10)	11 (10)

Sources: Defra Farm Practices Survey 2009, 2012

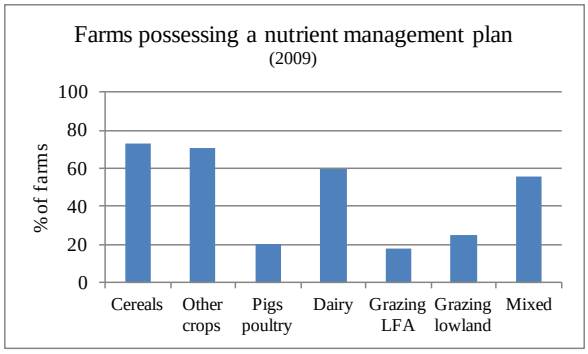
Between 2009 and 2012, there was little change in the sources of professional advice used in preparation of nutrient management plans, the main source remaining fertilizer advisers/agronomists (Table 3). Animal nutritionists were used as a source of professional advice mainly by dairy and grazing livestock enterprises in LFAs (around 30% of these holdings reported as using them).

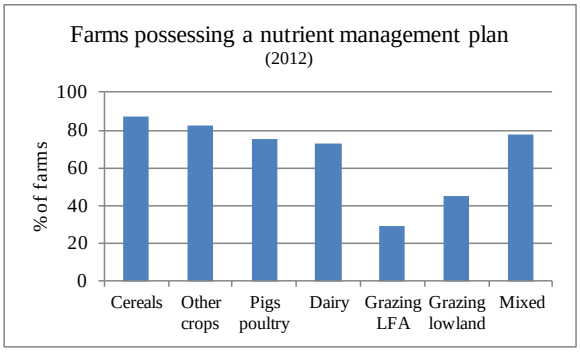
Table 3 Source of professional advice in 2012
(% of holdings with a plan, 2009 values in parentheses)

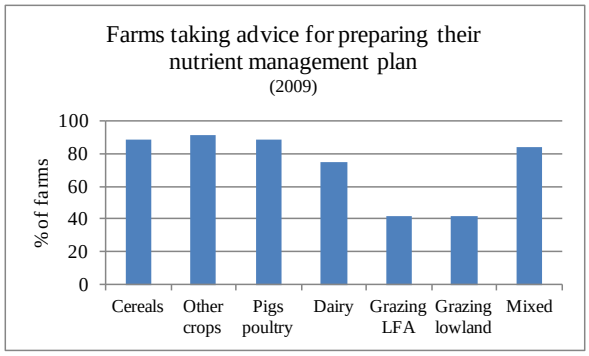
Fertilizer adviser/agronomist	82 (86)
Animal nutritionist	7 (5)
FWAG adviser	4 (7)
Other	13 (10)

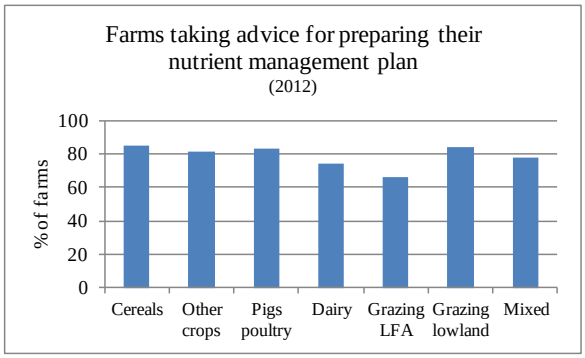
Source: Farm Practices Survey, 2009, 2012

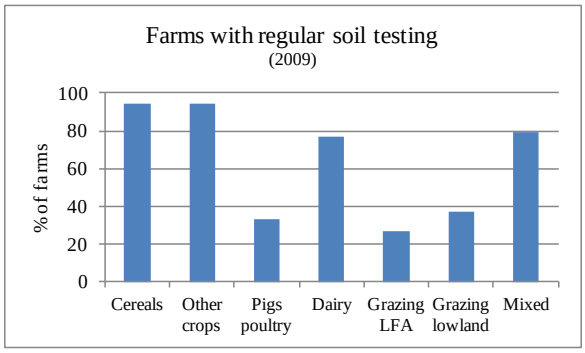
Fig 1 Changes in nutrient management planning 2009 to 2012

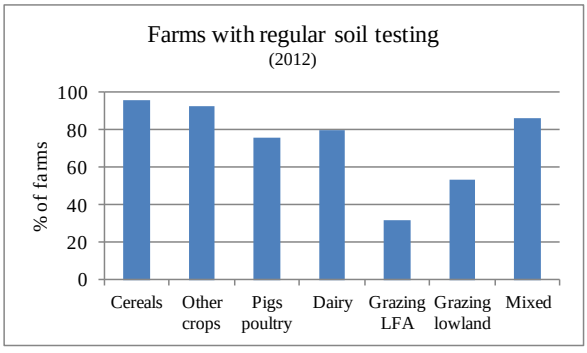


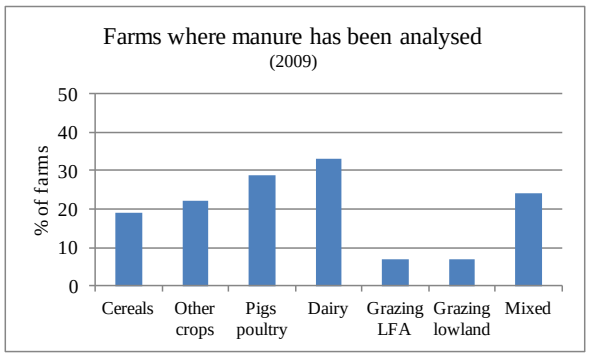


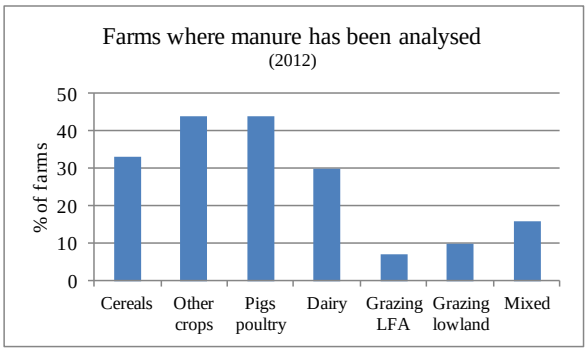


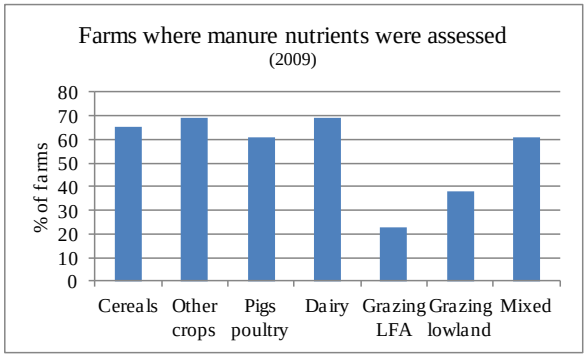


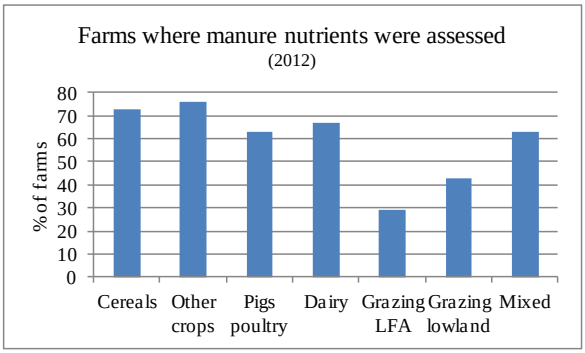












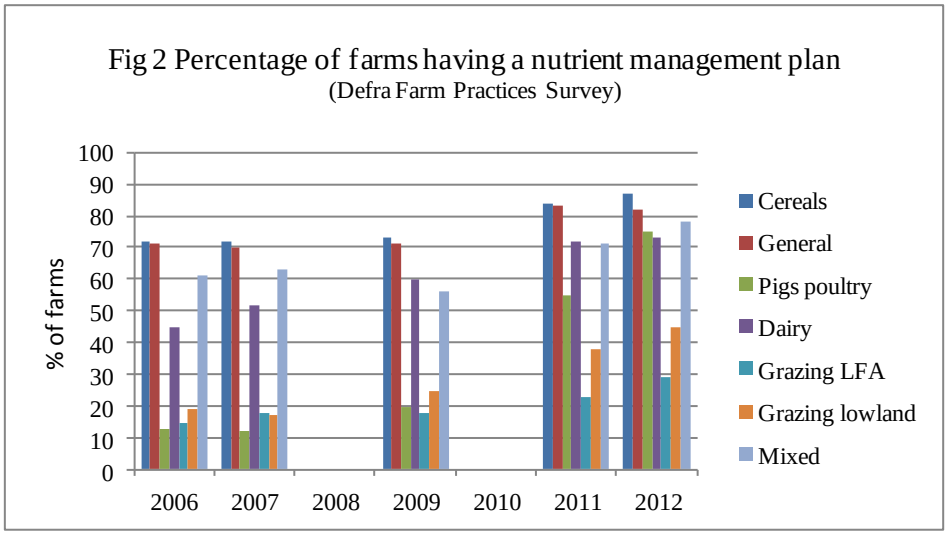
1.4 Trends in use of nutrient management plans

Some information on trends can be gained by comparing the Farm Practices Survey of 2012 with those of 2006, 2007, 2009 and 2011. The percentage of all holdings surveyed that reported possession of a nutrient management plan increased steadily from 46% in 2006 to 68% in 2012 (Table 4). There was a particularly large increase from 13% to 75% in pig and poultry farms that is encouraging but needs confirmation. Reported possession of a plan remained lowest in grazing livestock farms though there were increases from 19% to 45% in lowland grazing farms and from 15% to 29% in LFA grazing farms.

Table 4 Holdings with a nutrient management plan
(% of all holdings)

	2006	2007	2009	2011	2012
Cereals	72	72	73	84	87
General cropping/horticulture	71	70	71	83	82
Pigs and poultry	13	12	20	55	75
Dairy	45	52	60	72	73
Grazing (LFA)	15	18	18	23	29
Grazing (lowland)	19	17	25	38	45
Mixed/other	61	63	56	71	78
All holdings	46	47	51	62	68

Source: Farm Practices Survey, 2006, 2007, 2009, 2011, 2012



1.5 Tried & Tested

The paper-based Tried & Tested nutrient management plan was launched in March 2009. It was designed to meet the requirements for a nutrient management plan set out in Protecting our Water, Soil and Air (Defra 2009).

The Farm Practices Survey indicated that 68% of all farms reported possession of a nutrient management plan and 16% of those with a plan reported use of Tried & Tested. This amounted to around 6600 farms with Tried & Tested, an increase from the 3400 farms calculated in a similar way from 2009 Survey data. Postage records from the NFU distribution centre showed 5804 copies of the Tried & Tested nutrient management plan were issued in hard copy between April 2011 and December 2012. Taking account of the numbers issued before April 2011 and the availability of downloadable versions at the Tried & Tested

web site, postage records were consistent with the survey value.

Other items have been developed and introduced under the Tried & Tested brand. Between April 2011 and December 2012, 9989 hard copies of Think Manures, 9082 hard copies of the leaflet New to Nutrient Management Guide and 4929 USB memory sticks holding the Fertiliser Manual and NVZ guidance leaflets have been issued.

1.6 PLANET

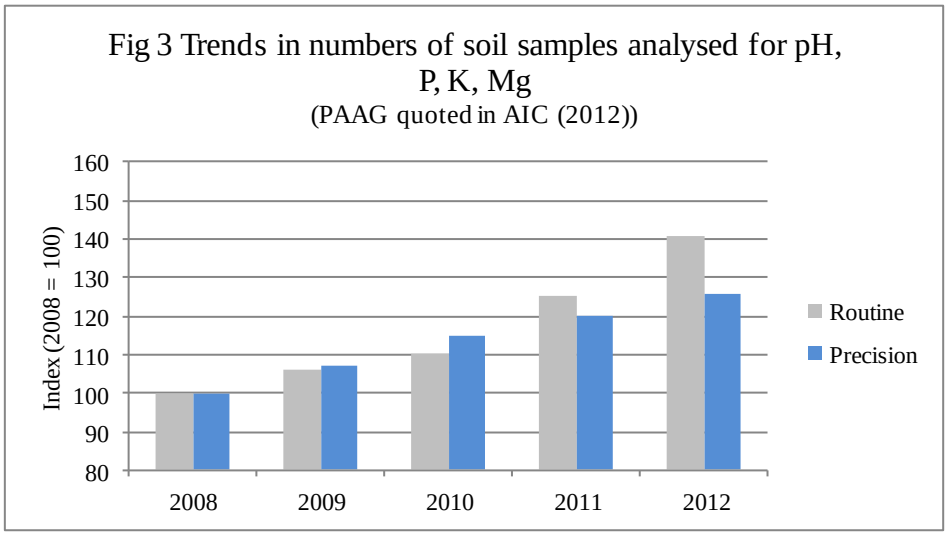
PLANET, software for nutrient related decision-making and recording, was developed by ADAS with funding from Defra for use in England and Wales only and was launched in 2004. The latest version, 3.2, was introduced in March 2012 and includes PLANET Scotland, previously available as separate software. The Defra Farm Practices Survey for 2012 indicated that 17,000 farms (28% of the 61,000 farms surveyed) reported use of PLANET.

1.7 Soil testing

The 2012 report of the Professional Agricultural Analysis Group (downloadable at www.nutrientmanagement.org) summarized results from more than 200,000 soil samples taken from arable and grassland in England, Scotland and Wales and analysed by the participating UK laboratories. These samples were from whole-field sampling and excluded samples taken in precision farming. Allowing for work by non-participating laboratories, the number of routine advisory soil samples taken in 2011/2012 probably was around 250,000. The agricultural area of Great Britain for which soil testing would be recommended (arable and horticultural crops, temporary and permanent grass) was 13,371,000ha in 2012 (Defra June Survey). The 250,000 soil samples therefore are equivalent to an average 53 ha/sample. If fields are sampled on average every four years, this is equivalent to around 13 ha/sample. This seems an encouraging intensity of sampling and consistent with the 45,000 farms that reported regular soil analysis (Table 1, 74% of 61,000 farms). However, the Farm Practices Survey revealed significant differences between farm sizes and between farm types (Table 1, Fig 1).

In 2012, the members of the Professional Agricultural Analysis Group (PAAG) were asked how sample numbers had changed in recent years. Their aggregated response indicated there had been significant increases in numbers of samples for routine (field) analysis and for field mapping (precision) since 2008 (Fig 3).

Fig 3 Trends in numbers of soil samples analysed for pH, P, K, Mg
(PAAG quoted in AIC (2012))



1.8 PDA calculator

In 2012, the Potash Development Association launched software that calculates phosphate and potash offtake in harvested crops and, if soil Indices are lower than target, estimates the amount of phosphate or potash that will have to be applied for correction (PDA 2012a). The software can be used on-line or downloaded to PC or mobile device. Use of the Calculator will help distinguish maintenance applications to replace offtake (costs of which should be charged to the crop) and soil Index correction (cost of which should not be charged to the crop but accounted for separately).

1.9 MANNER-NPK

More than 10,000 copies of MANNER v3 have been distributed since 2000 (Chambers *et al.* 2010). MANNER is easy to use and provides practical information that advisers and farmers can adopt. MANNER has been developed to provide estimates for manure phosphate, potash, sulphur and magnesium supplies as well as nitrogen. This new version, MANNER-NPK will be launched as stand-alone software in early 2013, downloadable at www.planet4farmers.co.uk.

1.10 Manure analysis

Relatively little change was reported in the percentages of farms where the nutrient content of manures was assessed or measured (Table 1). A recently completed Defra LINK project that involved HGCA, DairyCo, Potato Council, EBLEX and BPEX has shown the value of Near Infra-red Reflectance Spectrometry (NIRS) for fast analysis of manures (AHDB 2011). The technique has been commercialised at an analytical cost of around half that for conventional wet chemistry methods. It seems likely that the availability and promotion of this lower-cost technique will lead to more widespread analysis of manures and so greater efficiency in their use.

1.11 Crop sensing

In 2012, 235 tractor-mounted N-Sensors were reported to be in use in the UK, increasing at a rate of 30-40 per year (Yara, personal communication).

1.12 Spreader calibration and tray testing

The 2012 Defra Farm Practices, but not earlier Surveys, collected information on fertilizer spreader tray testing (Table 5).

Table 5 Percentage of farms checking the spread pattern of fertilizer spreaders

	More than once per year	Once per year	Once every two years	Less than every two years
Cereals	35	54	6	5
Other crops	39	50	7	4
Pigs and poultry	23	52	5	20
Dairy	20	44	13	22
Grazing livestock (LFA)	7	47	7	39
Grazing livestock (lowland)	9	54	4	33
Mixed	23	47	13	17
All farms	23	50	8	18

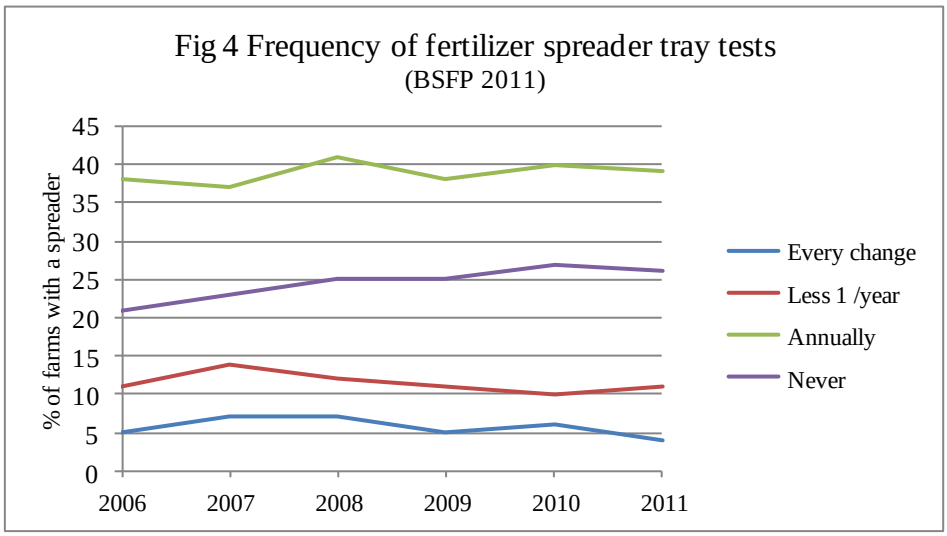
Source: Defra Farm Practices Survey 2012

Table 6 Percentage of farms calibrating fertilizer spreaders for rate of application

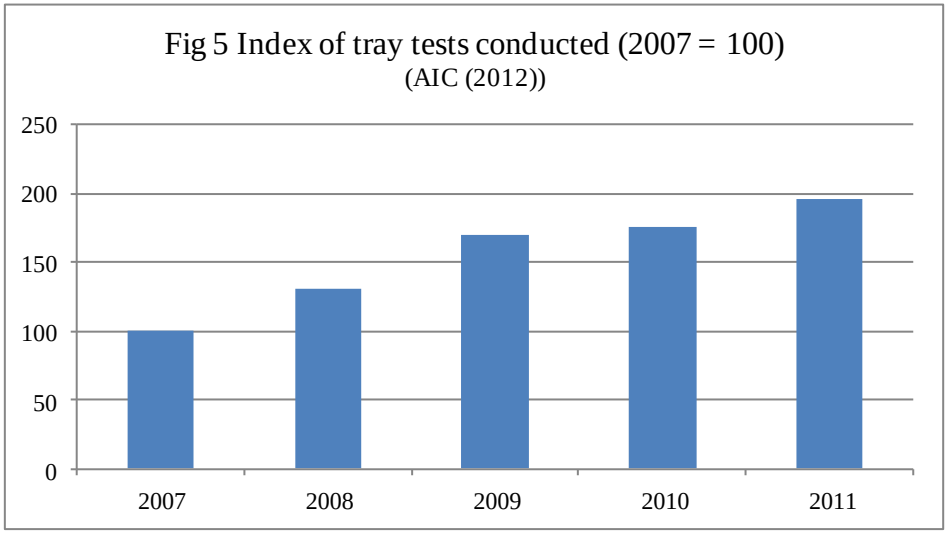
	More than once per year	Once per year	Once every two years	Less than every two years
Cereals	72	25	1	2
Other crops	73	23	4	1
Pigs and poultry	56	41	0	3
Dairy	49	39	5	8
Grazing livestock (LFA)	27	49	5	20
Grazing livestock (lowland)	35	49	3	14
Mixed	65	25	2	8
All farms	55	34	3	8

Source: Defra Farm Practices Survey 2012

Trend data were available from the British Survey of Fertiliser Practice (BSFP 2012) where the same question on spreader testing had been included from 2006 to 2011. These indicated no great change in use of tray tests to check evenness of spreading (Fig 4).



However, information from a major spreader testing organization, reported in the Greenhouse Gas Action Plan (AIC 2012), showed a doubling in the number of tray tests between 2007 and 2011 (Fig 5). It is difficult to reconcile these two sources of information. It is possible there has been a move from testing by farm staff to professional testing.



Developments in fertilizer spreader technology are reflected in the percentages of farms reporting possession of machines with some element of computer control. As might be expected, uptake of this technology is lowest in the grazing livestock farms (Table 7).

Table 7 Percentage of farms that have at least one computer-controlled fertiliser spreader with variable rate application

	At least one computer-controlled fertilizer spreader
Cereals	35
Other crops	35
Pigs and poultry	28
Dairy	10
Grazing livestock (LFA)	3
Grazing livestock (lowland)	2
Mixed	16
All farms	19

Source: Defra Farm Practices Survey 2012

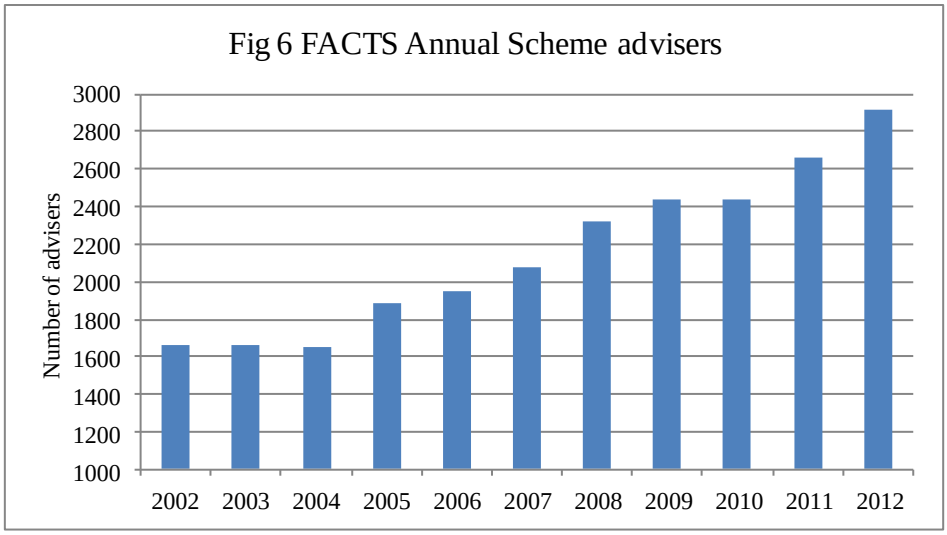
1.13 Advisers

Advisers are important as they assist farmers in nutrient management planning and they have a magnifier effect on uptake of some planning tools. 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 Fertiliser Manual/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 by farm consultants (often members of AICC or BIAC). Most nutrient management advisers who deal directly with farmers are now FACTS qualified.

FACTS was introduced in 1992 and converted to an annually renewable scheme in 2002.

Since then the number of FACTS advisers who subscribe to the annual scheme has increased to nearly 3000 in 2012 (Fig 6).



Changes to the scheme in 2010 require all members to undergo formal training on a five-year rolling basis to help ensure they remain up-to-date as FACTS Qualified Advisers (FQAs). A technical information service comprising email and phone help-lines, quarterly newsletter and on-line library is available to FQAs. This provides email and phone communications with all of the advisers allowing messages and new information to be disseminated rapidly and cheaply to almost all farm advisers dealing with nutrients.

1.14 Levy funded R&D

AHDB-funded R&D is a major source of new information and ideas that promote change in nutrient management. Involvement of AHDB sector organizations in developing NIRS for manure analysis is noted in 1.10 above.

HGCA invests more than 50% of cereal and oilseed levy income in research and knowledge transfer and a significant part of this relates to crop nutrition. The nutrition research programme includes the collaborative European project END-O-SLUDG to develop fertilisers from biosolids; Critical-P that evaluates crop responses to phosphorus and the rate of decline in availability of soil phosphorus and Auto-N that is developing commercially-viable systems for automatic adjustment of nitrogen rate during spreading. Management guidelines and Topic Sheets covering cereals and oilseeds bring research findings to farmers and advisers in accessible forms.

EBLEX in 2012 published Manual 7: Managing nutrients for better returns as part of the Better Returns Programme. DairyCo developed the Grass+ guide to improve grassland management and to optimise fertilizer nitrogen practice.

The Potato Council funds research results of which are made available at the web site. Recent nutrient-related reports cove the potassium requirement of potatoes and canopy and nitrogen management. HDC also funds research and publishes results at the web site. Research findings are made accessible in grower Factsheets, recent subjects including Nitrogen requirements for leeks and Soil Nitrogen Supply for field vegetables.

2.0 Changes in nutrient management practices

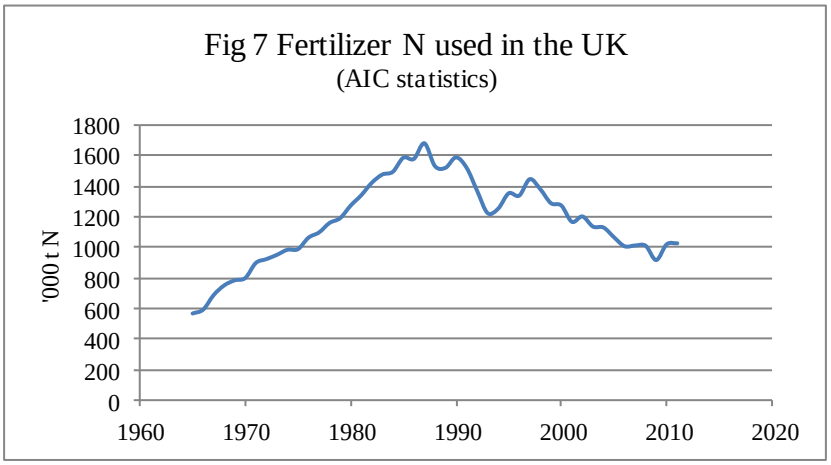
2.1 Nutrient management - planning and practices

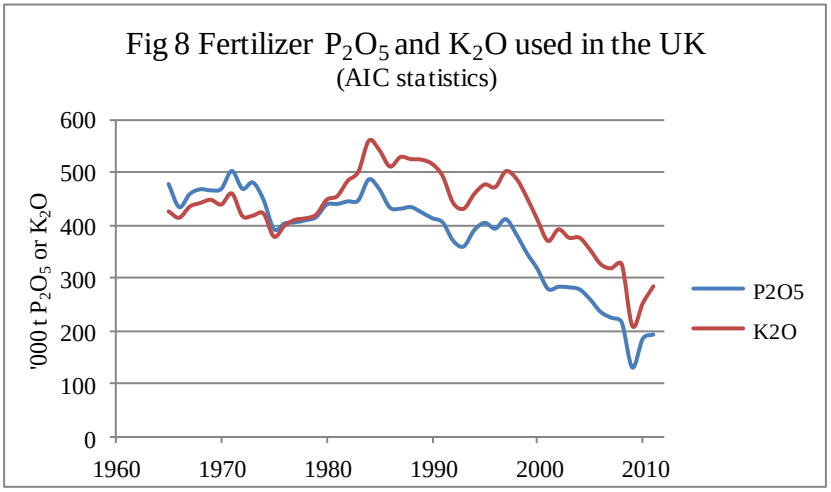
Changes in the use of nutrient management tools eventually should lead to detectable trends in management practices. There will be delays and lags between the introduction or adoption of new tools and consequent effects on measurable variables such as nutrient use. It is helpful therefore to look at longer term trends in practices rather than at changes over a few recent years.

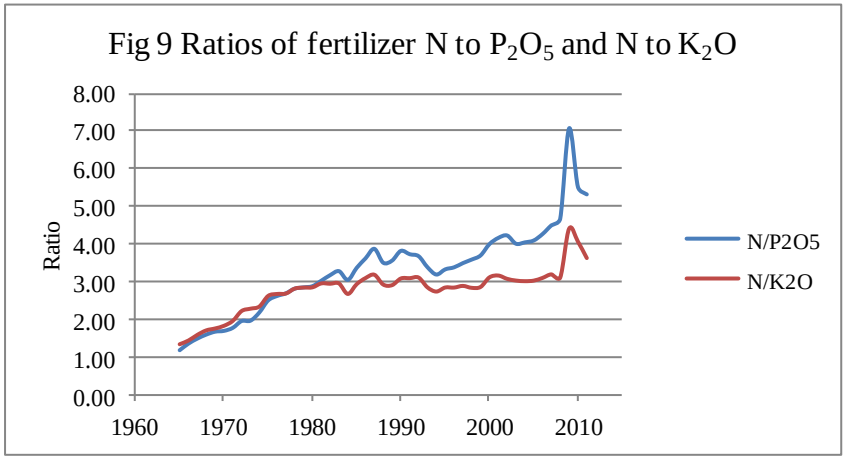
2.2 Use of nutrients and lime

Use of manufactured fertilizer nitrogen, phosphate and potash peaked in the UK around 1985 and has declined significantly since (Figs 7, 8). The ratios of fertilizer nitrogen to phosphate and to potash increased steadily from 1960 but very markedly in 2009 (Fig 9). From 2010, the ratios have decreased to values that would be projected from the trend in 1960-2008. While this has restored the balance of nutrient use to some extent, it seems likely that the ratios remain too wide for long term sustainability of balanced soil nutrient supply.

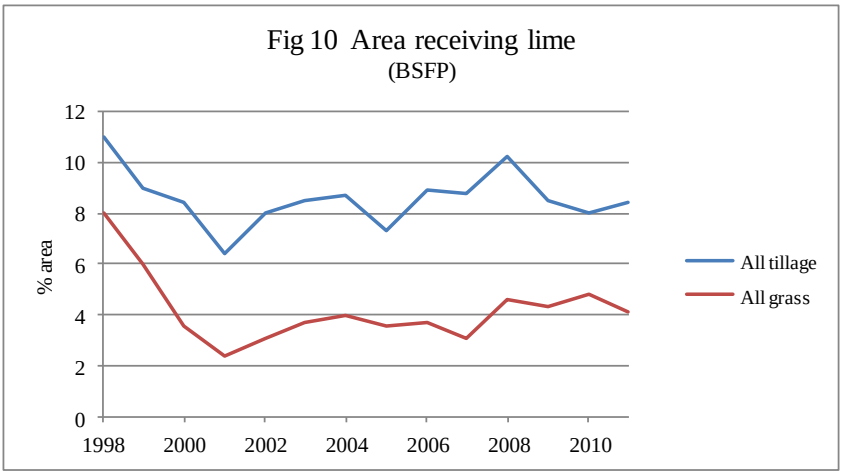
Significant differences between England/Wales and Scotland in use of fertilizer phosphate and potash have been reported (PDA 2012b based on BSFP data). In the early 1980s, practices in both parts of the UK were similar but since then, use of phosphate and potash has decreased much more greatly in England/Wales than in Scotland. In 2010/11, these fertilizer nutrients were applied to around 45% of arable land and 37% of grassland in England/Wales. By contrast the corresponding values for Scotland were around 83% for arable land and 58% for grassland.







The percentage of tillage crop and grass areas to which lime was applied (BSFP data) has tended to increase slightly in the past decade after a decrease in the late 1990s (Fig 10). Nevertheless, the average liming interval of around twelve years in tillage crops and twenty five years in grassland appears inadequate to maintain soil pH.



2.3 Soil Indices

Detailed information on soil pH and P and K Indices are published annually by the Professional Agricultural Analysis Group (PAAG 2012). PAAG membership includes the main laboratories offering soil analysis for crop advisory purposes in the UK and the data published are summaries of their aggregated analytical data.

In 2011/12, 10% of arable and 8% of grassland soil samples were at target indices for both P and K (Tables 5, 6) indicating scope for improvement. 24% of arable and 37% of grassland soil samples were below target P index (2) and 31% of arable and 42% of grassland soil samples were below target K index (2-). The ability of the crops to take up and utilize nitrogen will be compromised at these low P and K indices leading to restricted crop growth and increased risk of nitrogen loss to the wider environment. The long-term trend in fertilizer phosphate and potash use will not lead to any improvement.

There is an apparent inconsistency between reported widespread soil sampling, supported by sample numbers reported by the main laboratories, and the continuing downward trend in fertilizer phosphate and potash use and the small proportion of samples at target indices. It seems soil samples are being taken and analyzed (at a total annual analytical cost of some £2 million for routine analysis) but that results are not being acted on to ensure adequate phosphate and potash supplies to crops.

Table 5 Percentages of samples in P and K Indices

(PAAG, total 60042 samples)

	P Index		
K Index	<target	target	>target
<target	10	9	12
target	7	10	15
>target	7	11	20

Table 6 Percentages of grass samples in P and K Indices

(PAAG, total 38266 samples)

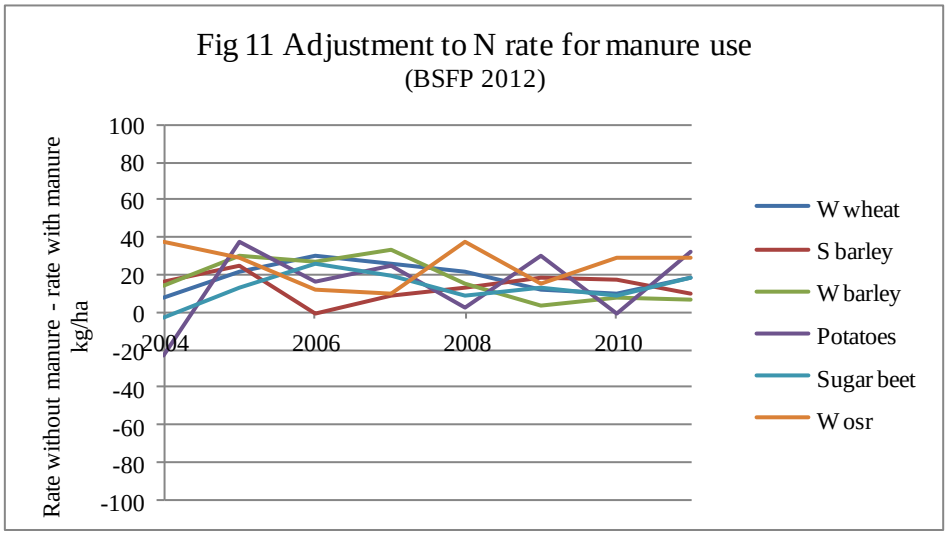
	P Index		
K Index	<target	target	>target
<target	20	12	10
target	10	8	8
>target	7	9	15

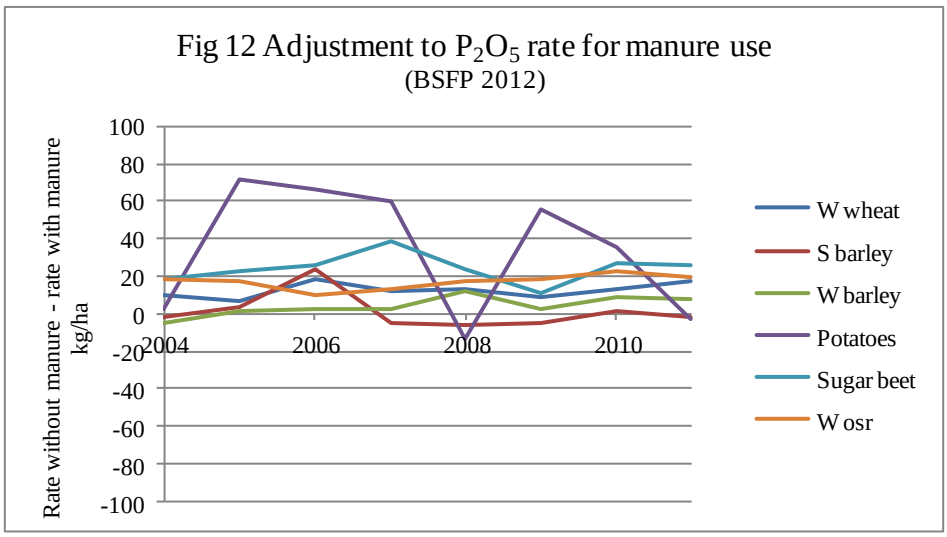
In the PAAG report for 2011/12 soil pH was lower than 6.0 in 20% of arable samples and lower than 5.5 in 23% of grassland samples.

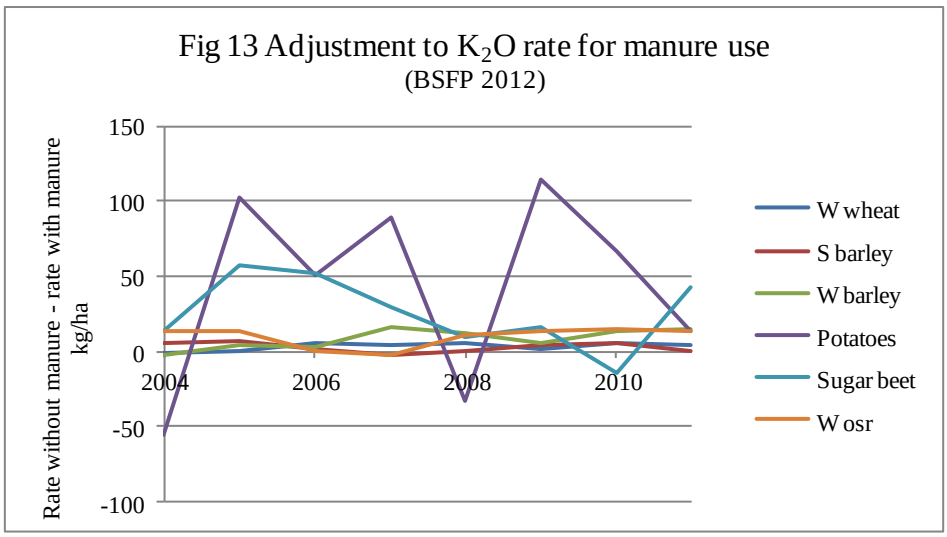
2.4 Allowance for nutrients in manures

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 2012) of 20 t cattle FYM/ha or of 30 m^3 cattle slurry/ha will supply around 12-25 kg crop available N/ha, 40-70 kg total P_2O_5/ha and 100-160 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 consistent with the likely amount applied in manures, around 20 kg N/ha (Fig 11). However, adjustments to fertilizer phosphate and, especially, potash mostly were less than 20 kg/ha and smaller than the amounts likely to have been applied in manures (Figs 12, 13). Adjustments

in potatoes and sugar beet sometimes were greater than this but were variable from year to year. 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.







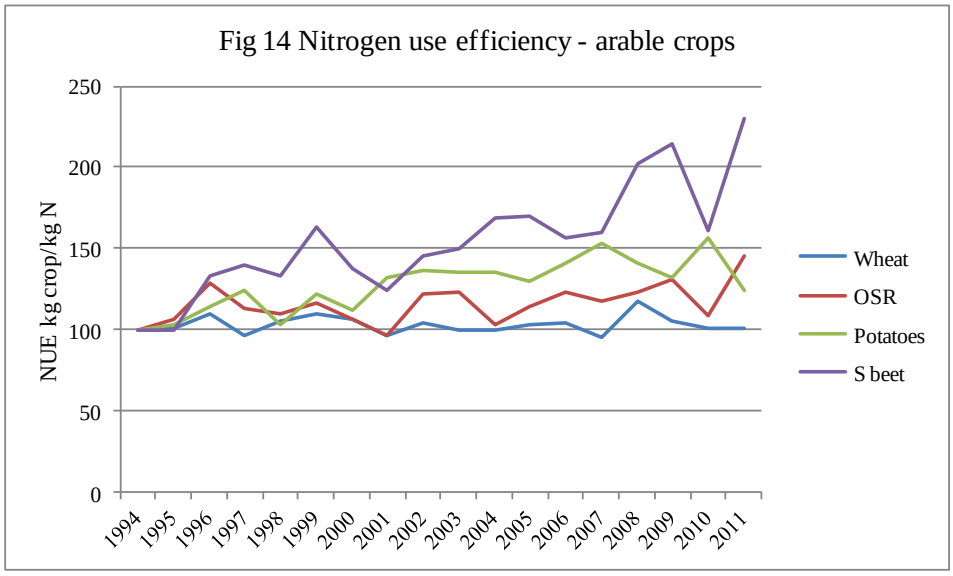
3.0 Nitrogen use efficiency

3.1 Method of calculation

There are several definitions for nitrogen use efficiency (NUE) though all involve a ratio of a measure of output or production to one of nitrogen input. For present purposes, NUE (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.

3.2 Arable crops

UK average yield data were available from Defra statistics for four main arable crops: wheat, oilseed rape, maincrop potatoes and sugar beet. Overall nitrogen application rates for GB (England, Scotland and Wales) were available from The British Survey of Fertiliser Practice. The discrepancy between UK and GB was unlikely to have affected calculated trends significantly (for sugar beet, not at all). Calculated trends, normalized so that the 1994 value for each crop = 100, are shown in Fig 14.



Over the period 1994 to 2011, NUE for wheat remained 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 yield/nitrogen applied, will increase as nitrogen rate decreases. If no fertilizer nitrogen is applied, there will still be a substantial crop yield so NUE will be infinitely large.

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 2011. Trends in yield (1995 = 100) showed a large increase for sugar beet but much smaller increases for the other crops, especially wheat (Fig 15). The increase in oilseed rape yield in 2011 might be anomalous. Overall nitrogen application rates were quite stable for wheat and oilseed rape but decreased significantly for potatoes and, especially, for sugar beet (Fig 16). Trends for the four crops can be summarized:

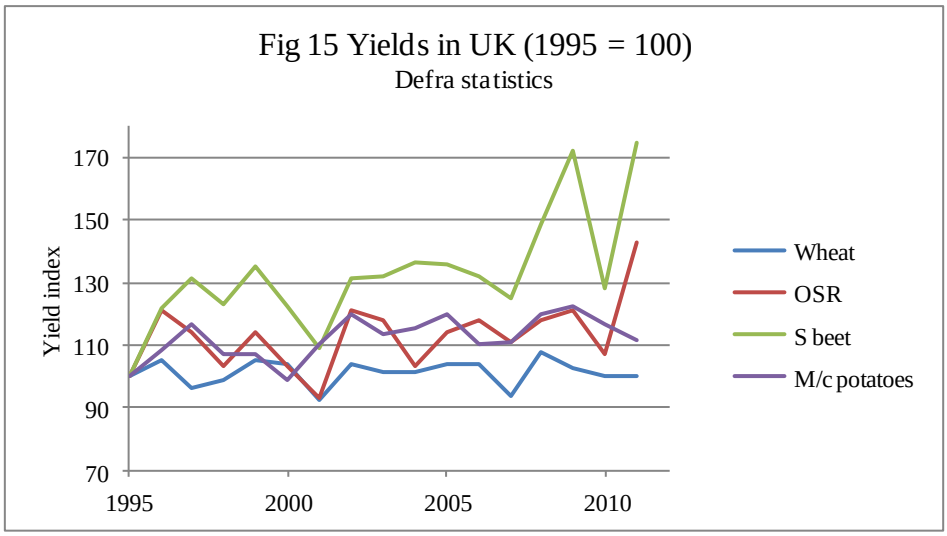
Wheat: no significant changes in yield, nitrogen rate or NUE.

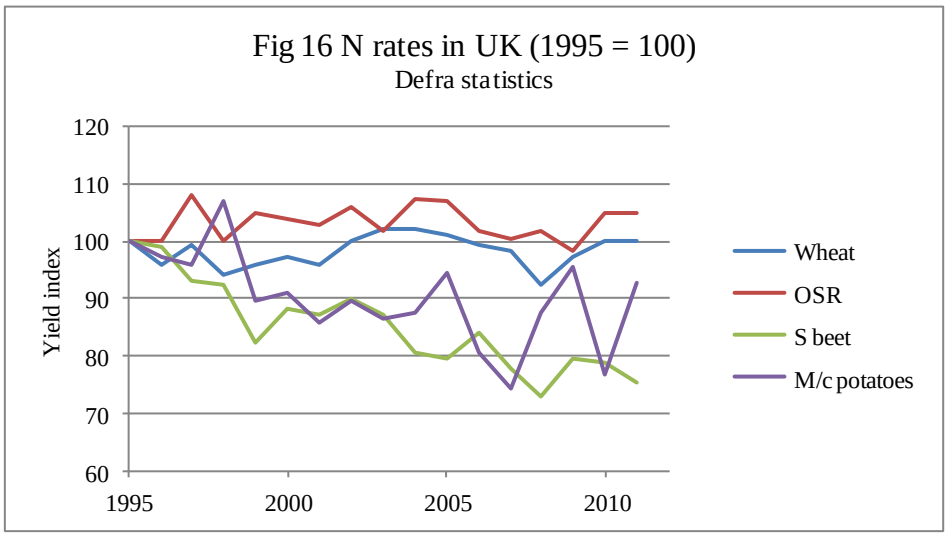
Oilseed rape: No significant change in nitrogen rate, small increases in yield and NUE.

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.

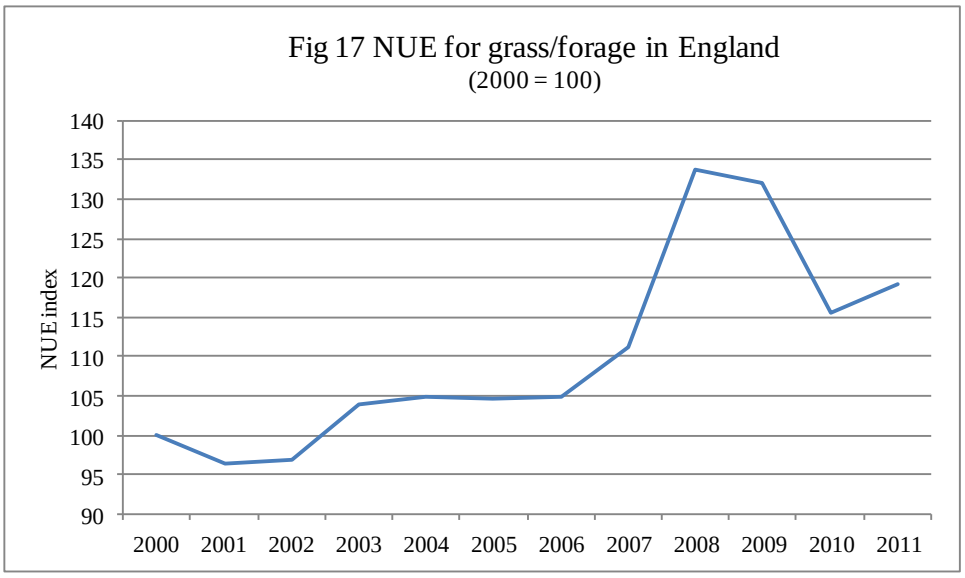


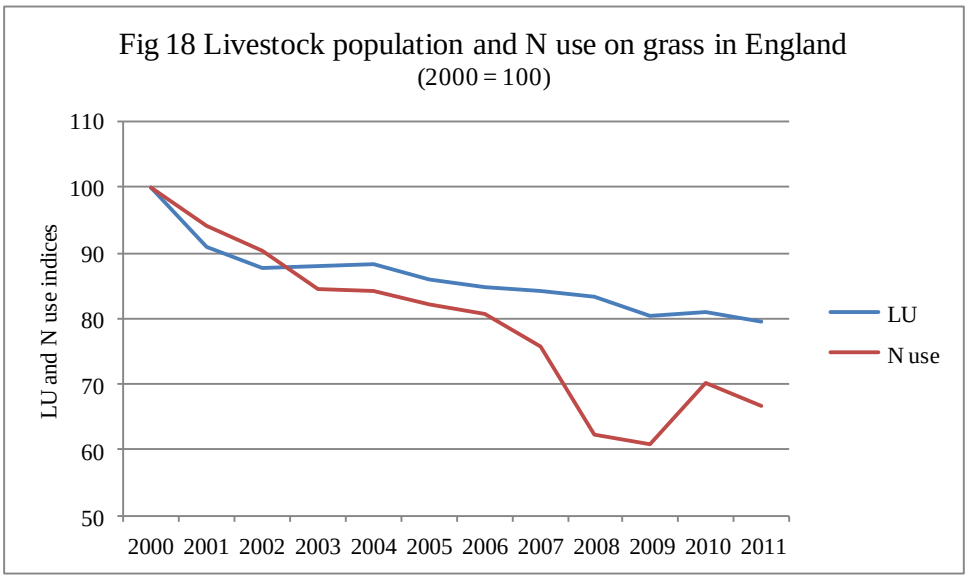


3.3 Grassland

A different approach was needed for grassland to take account of the data that were available. For present purposes, NUE for grassland is 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. 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 tended to increase during the past decade (Fig 17). 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 18). Overall, the data indicate a substantial increase in grassland NUE probably due to extensification rather than to improvements in nutrient management practices.





4.0 Future requirements and opportunities

There are several areas where change particularly needs to be promoted:

4.1 Use of nutrients in manures

It seems that the nutrients in manures are not being exploited fully or at least their application is not resulting in a corresponding change in fertilizer use. Launch of MANNER-NPK in 2013 offers an opportunity to raise awareness of manure nutrients. Joint promotion with Think Manures and the new NIRS analytical service could lead to improvements.

4.2 Grazing livestock farms

These farms have relatively low uptake of nutrient management tools. Partly this will be due to cost or complexity but the Tried & Tested nutrient management plan seems to have made good progress and this would support the promotion of other paper-based management tools.

4.3 Soil analysis and use of results

Regular soil testing is reported by an encouraging percentage of farms but fertilizer phosphate and potash use continue the decline that began around 1995. Taking account of manure use, it seems likely that removals of phosphate and potash by the main arable crops exceed the amounts of these nutrients that are applied. The need therefore is to encourage better use of soil analytical results and the right rates of application to correct deficiencies.

4.4 Spreader calibration/tray testing, application protocols and operator training

Data and professional opinion indicates that there is scope for further improvements in the standards of all nutrient testing and application procedures for solid and liquid fertilizers and manures. There is an absence of industry-wide standard protocols, with the exception of the sprayer protocol, which applies to straight (single nutrient) inorganic fertilisers and to agrochemicals. Also there is no register of fertilizer spreader operators equivalent to the NRoSO national register for sprayer operators. Updated cost and benefit information would also help to raise awareness and interest in ensuring best practice for nutrient applications.

4.5 Comprehensive nutrient management

There is a need to shift perception of nutrient management from fertilizer use to control of total nutrient supply. There are many sources of nutrients on farms and some such as animal feeds are not always appreciated. All sources have to be taken into account for meeting crop requirement. The Tried & Tested feed plan for ruminants (in production) will help in this.

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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	3.0	197	45.5	135	55.0	93
2011	7.7	193	4.0	197	43.5	163	75.0	89

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

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