THE FERTILIZER ASSOCIATION OF IRELAND

NITROGEN, IN CROPS AND IN THE ENVIRONMENT

R. J. Stevens

TRENDS AND IMPLICATIONS OF FERTILIZER PHOSPHORUS USE IN IRELAND

H. Tunney

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Towards precision nitrogen use

Many management and environmental factors result in fertilizer nitrogen being used inefficiently by plants. Because of over-production of many commodities and increased concern about the environment and health, the pressure to lower or ban the use of nitrogen fertilizers in agriculture is increasing. Presently the greatest public concern is over the levels of nitrates in drinking water. There are many ways to try to control nitrogen usage (Table 1) but most would be unpopular with farmers and difficult to administer. The most acceptable option for farmers must be in precision farming following the best management practices established by valid research. What are the best management practices for fertilizer nitrogen on grassland? Do farmers apply nitrogen fertilisers only when and where they are needed? As the consequences of over-supply of nitrogen are not as serious for most grassland farmers as the consequences of under-supply and hence under-production, many opportunities must exist to refine nitrogen use on grassland.

Table 1 **Possible strategies to control losses of nitrogen from fertilized soils.**

1. Limit the amount of N added per hectare
2. Establish farm quotas for N.
3. Limit the acreage of N-fertilized crops.
4. Establish effluent standards for soil leachate.
5. Impose an effluent change related to nitrogen loss rates.
6. Impose a tax on N fertilizer.
7. Subsidise the use of lower application rates.
8. Establish a best management practice.
9. Increase research and education, and rely on voluntary response.

The nitrogen cycle is complex and much research information already exists on many of its components. The task of gathering, processing and evaluating all the complex information is not a task for the farmer but for the specialist advisor. Farmers need to be told how to continue to use nitrogen fertilizers whilst minimizing the losses and overcoming public concern. Valid research results must be available to enable good advice to be formulated. In this paper I shall give some examples of research results which increase our understanding of the grassland nitrogen cycle in cool temperate climates and which could be valuable for formulating advice on nitrogen use.

Factors influencing fertilizers nitrogen efficiency

The important processes of the nitrogen cycle are summarized in Figure 1. The aim of precision farming should be to maximize the removal of nitrogen in product and minimise inputs and losses.

Many of the factors (Table 2) influencing fertilizer nitrogen efficiency are management practices under the control of the farmer and the fertilizer industry.

Table 2 **Factors affecting fertilizer nitrogen efficiency.**

Management practices	Edaphic factors
Fertilizer type	Temperature
Application rate	Rainfall
Timing of application	Radiation
Application technique	Soil type
Liming	Soil moisture content
Sward species	Organic carbon content
Irrigation	Soil aeration status
Use of other chemicals	Soil porosity
Use of organic measures	Soil pH
Rotation	Soil microbial activity
Tillage practices	

To demonstrate that progress can be made in increasing nitrogen efficiency I shall discuss some results from recent experiments conducted by the Department of Agriculture for Northern Ireland.

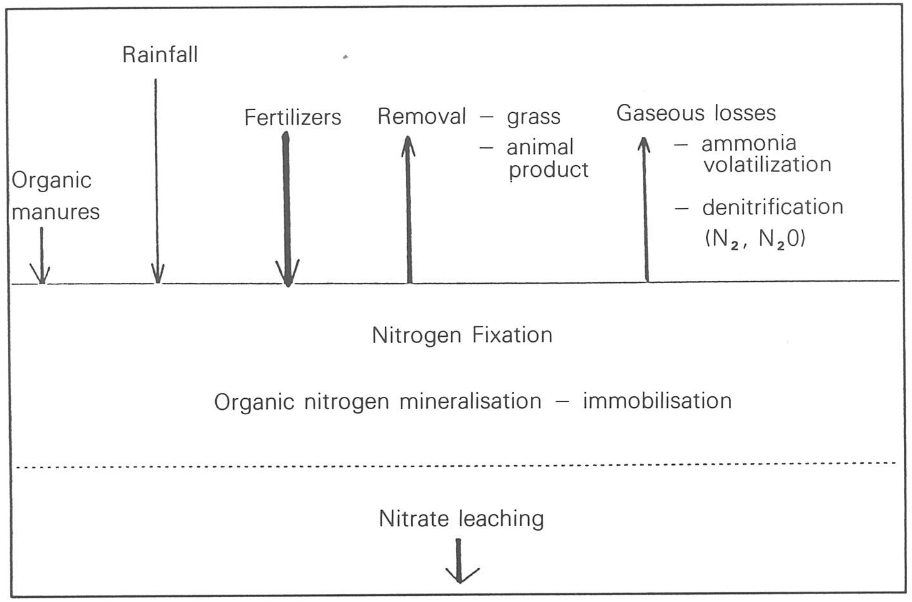

Figure 1 Inputs and outputs of nitrogen to grassland.

1. The recovery of ammonium nitrate and urea in grass and soil during one growing season.
2. The effect of time of application on calcium ammonium nitrate and urea efficiency.
3. Ammonia volatilization from urea.
4. The effect of a urease inhibitor on ammonia volatilization from urea.
5. The effect of soil pH and sward type on nitrogen offtake.
6. Nitrogen input/output budgets for a grazed grassland site.

1. The recovery of ammonium nitrate and urea in grass and soil during one growing season

Confined microplots were used to study the fate of ^{15}N-labelled ammonium nitrate and urea when applied to ryegrass in spring at 3 lowland sites. Urea and differentially and doubly labelled ammonium nitrate were applied at 50 and 100 kg N/ha. The % utilization of the ^{15}N-labelled fertilizer was measured in 3 cuts of herbage during the season and in soil to a depth of 15 cm immediately after the third cut. Average values over all forms and rates of fertilizer N (Table 3) show that 24% of the ^{15}N-labelled fertilizer must have been lost as gases, moved downwards below 15 cm or removed from the microplots by soil fauna. The % utilization values varied little with rate of application so losses of N increased from 12 to 25 kg N/ha as the rate of application increased from 50 to 100 kg N/ha. The total % utilization values over all sites for the different ^{15}N labelled fertilizers (Table 4) showed that urea was recovered with higher efficiency than ammonium nitrate and that the ammonium component of ammonium nitrate was recovered with higher efficiency than the nitrate component. Ammonia volatilization was prevented in this experiment by injection of the fertilizers as solutions below the soil surface. Ammonium-based fertilizers may be more efficient under Irish conditions.

Table 3 **Values of % utilization of ^{15}N labelled fertilizer in each of three cuts of herbage and in soil 0-15 over all forms and rates of fertilizer N at three sites.**

	% utilization		
	S1	S2	S3
% utilization at cut 1	53.7	48.8	54.8
% utilization at cut 2	5.1	5.3	5.4
% utilization at cut 3	2.3	2.4	2.5
% utilization in soil 0-15	16.2	18.0	13.4
Total % utilization	77.3	74.5	76.1

Table 4 **Values of total % utilization in herbage and in soil 0-15 of four forms of ^{15}N-labelled** fertilizer applied at 50 and 100 kg N/ha to 3 sites.

Site	Rate kg N/ha	% utilization $^{15}NH_4NO_3$	$NH_4{}^{15}NO_3$	$^{15}NH_4{}^{15}NO_3$	$(^{15}NH_2)_2CO$
S1	50	75.4	72.7	76.6	83.4
S2	50	76.7	68.1	76.3	82.3
S3	50	78.3	73.1	75.2	81.1
S1	100	78.2	70.8	75.8	84.9
S2	100	74.3	66.1	73.5	79.3
S3	100	77.4	65.4	76.7	80.9
Overall Average		76.7	69.4	75.7	82.0

2. Effect of date of application and form of nitrogen on herbage production in spring

Field plot experiments were carried out for 3 years at four sites to study the effect of date application of CAN and urea on perennial ryegrass production in spring. Fertilizer (70 kg N/ha) was applied at weekly intervals for 10 weeks from 1 February.

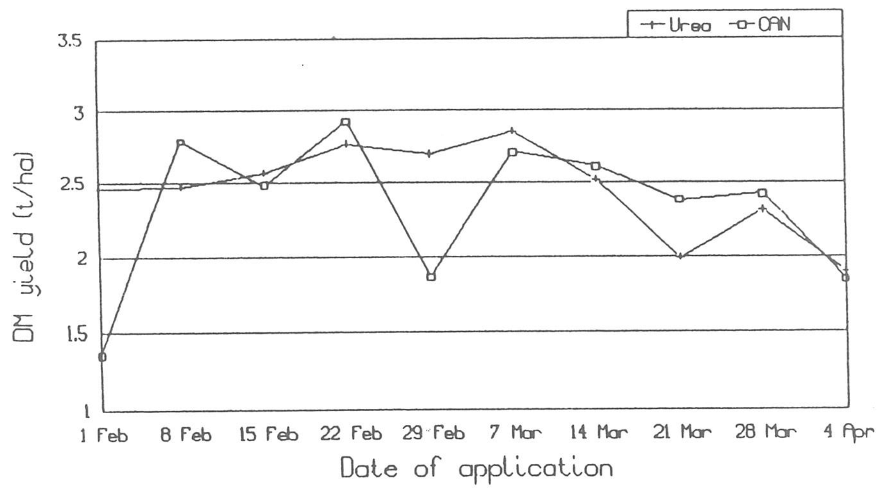

Figure 2. Effect of date of application of urea or CAN at 70 kg N/ha on DM yield of cut 1 at site 1 in 1984

Herbage was cut on the same day at all sites, 3-4 weeks after the last N application. CAN and Urea at 50 kg N/ha were immediately re-applied and a second cut of herbage was taken after 4-5 weeks.

The date of application for maximum yield at the first cut in 11 of the 12 site/years was in February. However the date of the application for optimum yield at the second cut was when the first application was on 5 April for 11 of the 12 site/years. The date of application for optimum total yield requires much less precise selection than the date of application for optimum yield at the first cut.

There was no significant difference between yields with urea or CAN at any site or date of application in 1983 and 1985. In 1984 yields with Urea were significantly greater than yields with CAN on 1 and 29 February at S1 and 27 February at S4. Results for CAN and urea at S1 in 1984 (Figure 2) illustrate that loss processes in the 7-day period immediately after application can decrease CAN efficiency. Factors related to rainfall had no significant effect on dry matter yield response due to urea, but dry matter yield response due to CAN was significantly decreased as the rainfall in the two days after application increased. Short-term rainfall probably increased urea efficiency by decreasing ammonia volatilization, but decreased CAN efficiency because of increased leaching and denitrification of nitrate. Choice of time of application should be influenced by weather forecast and nitrogen source.

3. Soil properties controlling ammonia volatilization from surface-applied urea

The rate and amount of ammonia volatilization from surface-applied urea were simulated for 36 soils by using ventilated enclosures. Daily losses were measured from each soil for 14 days. Examples of the pattern of daily losses are shown in Figure 3 for two soils. The total loss during the 14 day period was the same for both soils but the rate of loss in the first two days differed considerably.

The patterns of ammonia loss could be described by a sigmoidal curve constrained to go through the origin. Two characteristic properties of this curve were the total cumulative loss of ammonia as a % of the urea-N applied (A_{max}) and the time in days after urea application when the rate of ammonia volatilization was maximum (T_{max}). A_{max} values ranged from 1.6 to 26.1% and averaged 16.8%. T_{max} values ranged from 0 to 11 days after urea application. A_{max} was correlated with soil titratable acidity and T_{max} was correlated with soil urease activity and soil organic matter. Soils could possibly therefore be rated for susceptibility to ammonia volatilization loss with urea if these soil properties were known.

4. The effect of a urease inhibitor on ammonia volatilization from urea.

Urease inhibitors delay urea hydrolysis and increase the time available for sufficient rain to fall and move surface-applied urea into the soil, thereby preventing ammonia volatilization. N-(n-butyl) thiophosphoric triamide (NBPT) is currently the most effective soil urease inhibitor. In a field experiment, ammonia volatilization and yield response were measured when CAN, urea or urea + 0.5% NBPT were surface-applied to ryegrass. NBPT lowered cumulative ammonia loss (Figure 4) over 13 days from 8.1% of the urea-N applied to 1.9% and delayed by about 5 days the time at which maximum loss occurred. Ammonia volatilization from CAN was less than 0.1% of the N applied. NBPT improved the yield performance of urea making the amended fertilizer comparable to CAN (Table 5).

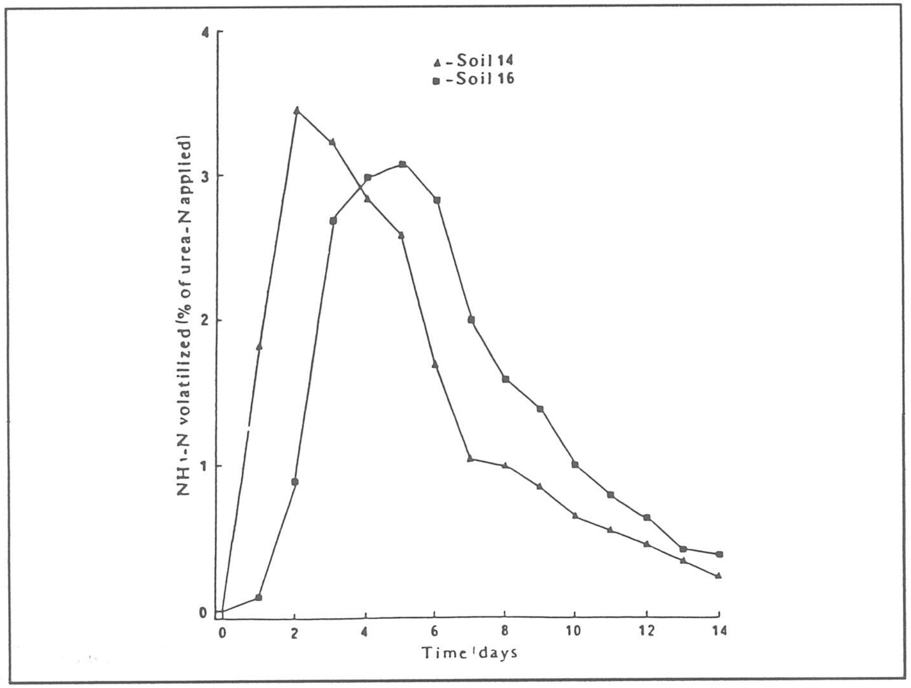

Figure 3. Daily loss rates of ammonia from two urea-treated soils with similar A_{MAX} but different T_{MAX} values.

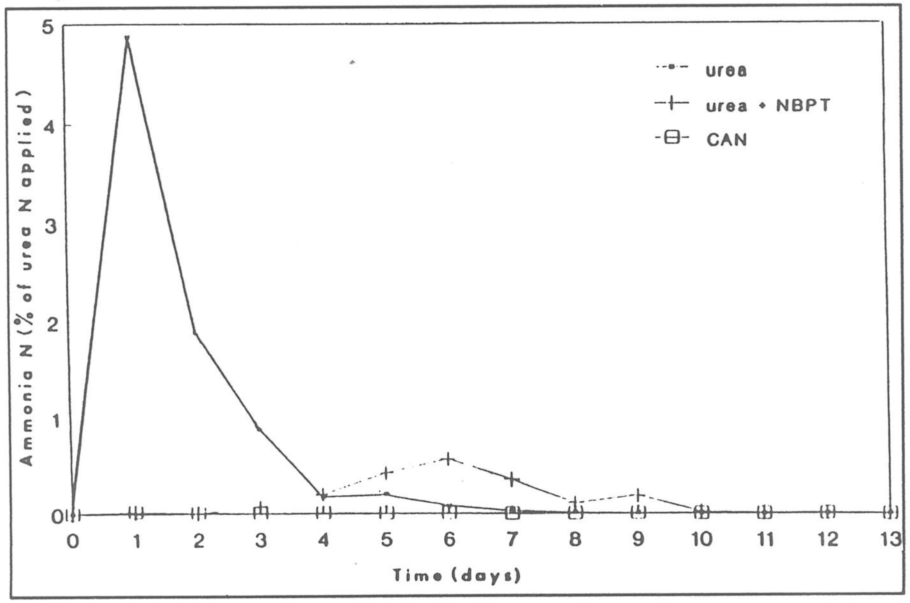

Figure 4. Daily loss of NH_3 N(%) from urea, urea + NBPT and CAN

Table 5 Performance of urea, urea + NBPT and CAN applied at 100 kg N/ha to ryegrass

	Control	Urea	Urea + NBPT	CAN
DM yield (t/ha)	0.6	2.9	3.3	3.3
Recovery of N (%)	–	57.0	69.0	69.0

5. The effect of soil pH on the nitrogen offtake by two sward types

The effect of liming on the yield and nitrogen offtake of permanent pasture and perennial ryegrass is being assessed in a long-term field experiment. Ground limestone was applied in 1983 at 0, 4, 8 and 12 t/ha. Nitrogen is applied at 160 or 320 kg N/ha/yr as CAN for 3 cuts of herbage. Data for five years (1984-1988) have been summarized for nitrogen offtake (Figure 5). At the low N rate the offtake by permanent pasture exceeds that of perennial ryegrass and is affected little by liming. The N offtake by perennial ryegrass increases with liming. At the high N rate the offtake by perennial ryegrass exceeds that by the permanent pasture. Liming has a negative effect on the offtake by permanent pasture. Full explanation of the interactions between liming, CAN and sward species are still being sought. Soil pH and sward species are important variables affecting fertilizer nitrogen efficiency.

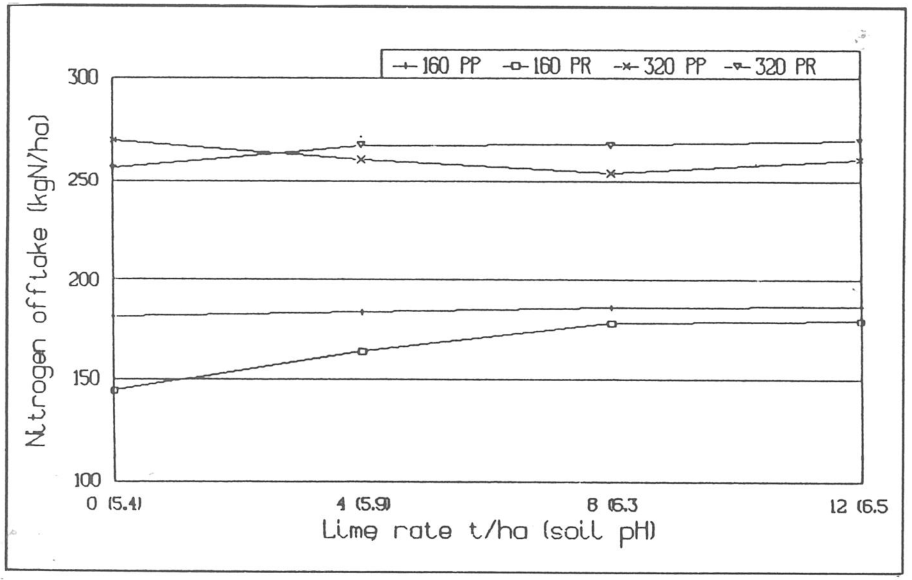

Figure 5. Effect of liming on the average nitrogen offtake (1984-1988) of permanent pasture and perennial ryegrass receiving 160 or 320 kg N/ha

6. The grassland nitrogen cycle under grazing

The grassland nitrogen cycle under grazing is being studied intensively on a field plot experiment at The Agricultural Research Institute at Hillsborough. Six plots (0.2 ha) were established in 1987. Each plot is isolated by moisture-proof barriers and is

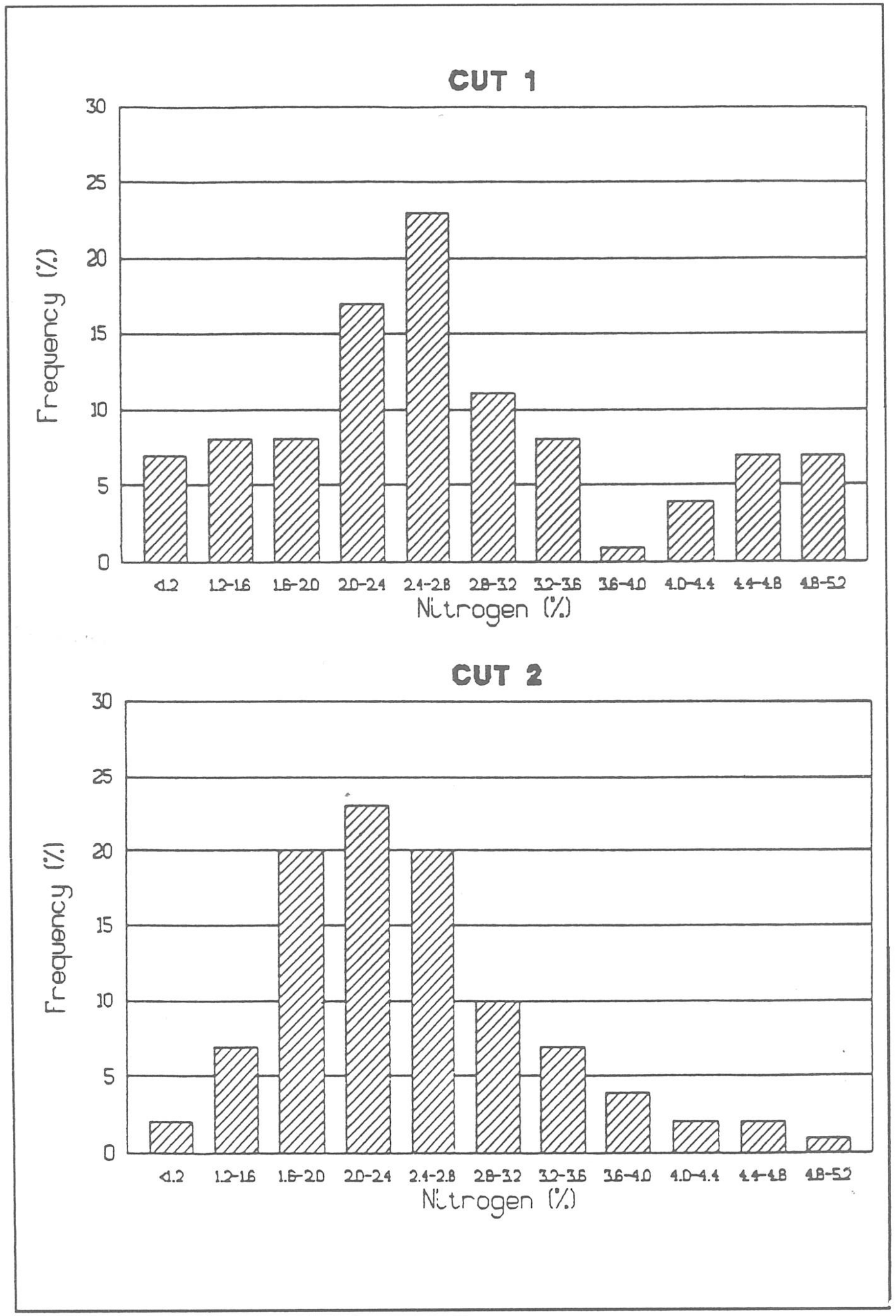

Figure 6. Nitrogen content of herbage on farms one week before cutting for silage

artificially drained to V-notch weirs with continuous flow recording and automatic sampling of drainage waters. The six treatments are a perennial ryegrass/white clover sward receiving no nitrogen fertilizer together with perennial ryegrass only receiving 100, 200, 300, 400 and 500 kg N/ha as CAN in 6 equal applications between March and August. Plots are grazed by beef steers to a constant sward height of 7 cm from April to September. Nitrogen inputs in precipitation and rainfall are measured. Outputs of nitrogen as liveweight gain, drainage and denitrification are measured and ammonia volatilization estimated from other work. Results for the first year of treatment (April 1989-March 1990) are shown in Table 6.

Table 6 **Inputs and outputs of nitrogen on grazed grassland for April 1989 to March 1990**

	Treatments Grass/clover Fertilizer applied (kg N ha^{-1})					
	(0)	100	200	300	400	500
Inputs						
Precipitation	6	6	6	6	6	6
Biological N Fixation	75	1	1	1	1	1
Fertilizer	–	98	196	294	392	490
Total Inputs	81	105	230	301	399	497
Outputs						
Liveweight gain	24	18	28	33	38	36
Total N leached	54	23	31	56	92	85
Denitrification	12	8	19	37	70	84
Volatilization	5	6	12	18	24	29
Total Outputs	95	55	90	144	224	234
Balance	-14	+50	+113	+157	+175	+263

Excluding the clover plot the initial leaching data show a significant fit to a linear model which indicated that the equivalent of 18% of N applied was lost in drainage water. The denitrification data also show a significant fit to a linear model which indicates that the equivalent of 21% of the N applied was lost by denitrification. The leaching loss from the grass/clover plot was similar to that from the 300 kg N/ha/yr treatment. Only the grass/clover plot shows an approximate equality of inputs and outputs. The N fertilized plots show a considerable imbalance with inputs exceeding outputs. It is likely that a substantial proportion of the nitrogen unaccounted for is being immobilized into soil organic matter. These increases will only be measurable over a 10-year time period.

Future research needs:

1. Little is known about the fate of fertilizer nitrogen in the first week after application. More information is required on rates of nitrogen uptake by roots, nitrate losses in water flow through macropores and protection of nitrate from leaching by diffusion into soil micropores.
2. More information is required on the rates of fertilizer nitrogen required to achieve the desirable optimum for grazing or for cutting. A survey of the nitrogen content of herbage one week before cutting for silage (Figure 6) showed a wide range of N concentration. Much more precision in nitrogen application is obviously required, both early and late in the growing season.
3. Urea has an inherent N loss mechanism by ammonia volatilization. There is an urgent need for a commercially acceptable urease inhibitor.
4. The losses of nitrous oxide by denitrification may become of more environmental concern. Nitrous oxide is implicated in global warming and in the catalytic destruction of the ozone layer.
5. The nitrogen losses under a grass/clover system need to be compared with losses under precision fertilizer nitrogen management.
6. The nitrogen losses when soils previously under intensive grazing are ploughed need to be quantified. Some evidence suggests that high leaching losses are possible, so autumn ploughing of such soils may be undesirable.
7. Research is usually carried out to satisfy curiosity, to create or refine knowledge and to solve problems. More research effort will be required to address public interest and concerns.

TRENDS AND IMPLICATIONS OF FERTILIZER PHOSPHORUS USE IN IRELAND

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1. Introduction

Irish soils are naturally very deficient in phosphorus because of leaching and removal in crops and animals over thousands of years. Many people still remember the very severe deficiency symptoms that were common in animals up to the 1950's.

Phosphorus fertilizer use in Ireland started in the late nineteenth century but it was not until the start of this century that significant quantities were used. From 1900 to 1950 the average use of fertilizer phosphorus was in the region of 15,000 T per year. The very low phosphorus status of soils at this time indicated that this rate was not adequate. There was a rapid increase in use over the next 20 years up to a maximum of about 90,000 T in the early 1970's. There has been a gradual decline over the last 20 years to about 60,000 T at present. There is evidence that this rate may be higher than necessary.

2. Recent studies on crop response to phosphorus

Recent experiments at Johnstown Castle Research Centre indicate that some intensively farmed soils have built up considerable reserves of phosphorus. In an experiment based on sites at 3 Teagasc farms, Clonroche, Johnstown Castle and Oakpark, results over the past four years show that there was not a statistically significant response to fertilizer phosphorus despite the removal of the equivalent of 200 kg phosphorus per ha over the four years.

Pot experiments on soils from six Teagasc farms indicate some soils with high fertility, at Grange for example, may have adequate reserves to supply ten years silage production (400 kg phosphorus) without a response to fertilizer phosphorus. If animal manures are recycled to the silage area then the reserves will be adequate for a much longer period. More detailed results are available in the annual research reports of Teagasc, Johnstown Castle.

On most Irish farms fertilizer phosphorus is applied each year to maintain fertility but, because of existing reserves, there is no noticeable response in the year of application. This is in contrast with fertilizer nitrogen where there is almost always a noticeable response shortly after application.

3. Soil phosphorus status

The soil test used is based on extracting the soil with a solution of sodium acetate and acetic acid at pH 4.8, known as Morgan's reagent.

Soil analysis on samples from farms in the Republic of Ireland have been carried out at Johnstown Castle from the late 1940's. Most of the samples have been collected by the agricultural advisory officers and an average of about 80,000 soil samples per year have been analysed over the past 40 years.

Soil analyses show a continuing increase in soil phosphorus status (Tunney and Power, 1988). Fig. 1 shows that the average soil phosphorus test value has increased from about one in the early 1950's to nine at present. The relationship in figure 1 summarizes the results of several million soil tests.

The average of the phosphorus test from soil samples received in a year forms the basis of the relationship shown in Figure 1. These are not random samples in that the more intensive farmers use most fertilizer and are also more likely to send soil samples for analyses. Random samples show somewhat lower soil phosphorus test values (Brogan et al. 1981). The average values represent a wide spread, at present about 25% of samples are under 3, 25% over 10 and 50% between 3 and 10 mg phosphorus per kg soil.

4. Phosphorus fertilizer use

Figure 1 also shows the trend in use of fertilizer phosphorus over the past 40 years. This shows a rapid increase particularly from 1960 to the early 1970's. However from that time phosphorus use has not increased and from 1980 has levelled off at about 60,000 tonnes per annum. Despite this, the average soil test continues to increase. This suggests that phosphorus use is higher than the removal in agricultural output and in water draining from agricultural land.

The average soil pH of the samples shown in figure 1 was stable at pH 5.9 between 1954 and 1970. During this time the average soil phosphorus test increased from approximately 1 to 4 indicating that it increased independently of pH. The average soil pH increased to 6.2 by 1987 and it is unlikely that this small increase in soil pH has an important influence on the relationship shown in figure 1.

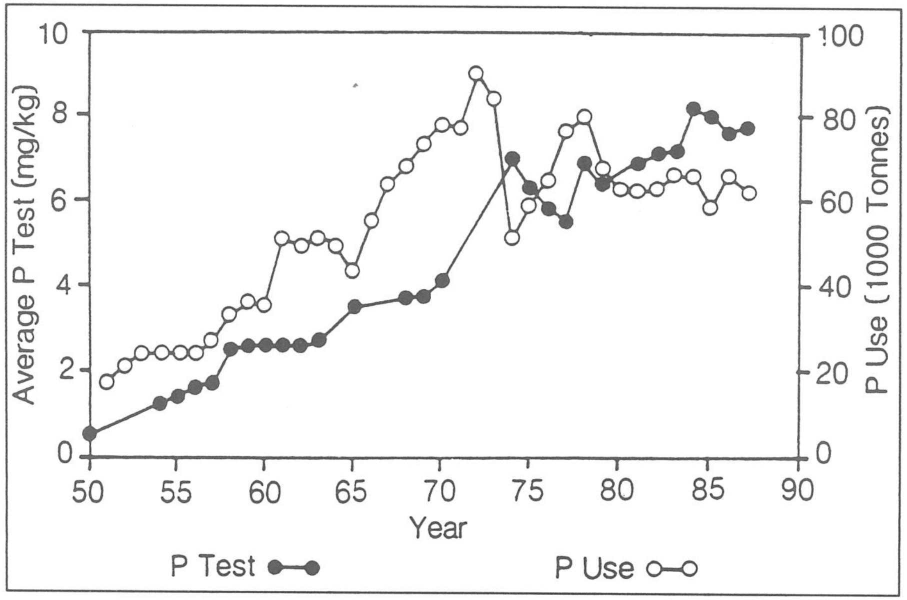

Figure 1 – Trends in the average soil test values and in fertilizer phosphorus use in the Republic of Ireland.

5. Phosphorus balance in Irish agriculture

A study in the early 1970's suggested that more phosphorus was being applied than removed (Hanley and Murphy, 1973). Another study in the early 1980's suggested again that more phosphorus was being applied than removed on many farms (Brogan et al. 1981).

Table 1. **Estimate of phosphorus balance for 1988 (tonnes P)**

Inputs		
– Chemical phosphorus fertilizer		62,446
– Concentrates fed cattle and sheep 1.8 x 10^6 T(5 g P/kg)		9,000
– Concentrates fed pigs and poultry 0.9 x 10^6 T(6.5 g P/kg)		5,850
	Total Inputs	77,296
Outputs		
– Tillage crops 451 x 10^3 ha (27 kg P/ha)		12,177
– Casttle and sheep production 1089.6 x 10^3 T (8 g P/kg)		8,717
– Milk 5,170 x 10^6L (1 g/P/L)		5,170
– Soluble P loss to water, 6.89 x 10^6 ha (0.5 kg P/ha)		3,445
– Pig and poultry production 291.0 x 10^3 T (6 g P/kg)		1,746
	Total outputs	31,255
Excess	Inputs-Outputs	46,041

The figures in table 1 are based on agricultural statistics and the average phosphorus composition of the various materials. The loss to water is based on a recent study (Toner and McGarrigle, 1989).

Phosphorus in clay particles is also lost to water. This loss is not included in the balance sheet, it may be about double the soluble inorganic phosphorus in water shown in table 1 (Copper and Thomsen, 1988). The estimate of total phosphorus in animal feed shown in table 1 is higher than the estimate of total removal in tillage crops. Approximately 1.7 of the 2.2 million T of cereals produced annually is fed to animals in addition approximately 1.0 million T of cereal concentrates are imported. Of the total of 14,850 T phosphorus in concentrates fed to animals about 4,000 T is in the imported concentrates and 4,000 T is imported in the form of dicalcium phosphorus. This means that the total imports into the Republic of Ireland in 1988, in fertilizers and feeding stuffs was of the order of 70,000 T phosphorus.

A major part of the national phosphorus cycle is in the manures from the grass and conserved grass eaten by ruminants. The total in animal manures is of the same order as applied in fertilizer (Tunney, 1980). However, it is not included in the balance as, in practice, it is generally recycled back to the land from which it is produced. For the purpose of this balance it is assumed that the phosphorus in animal manure comes

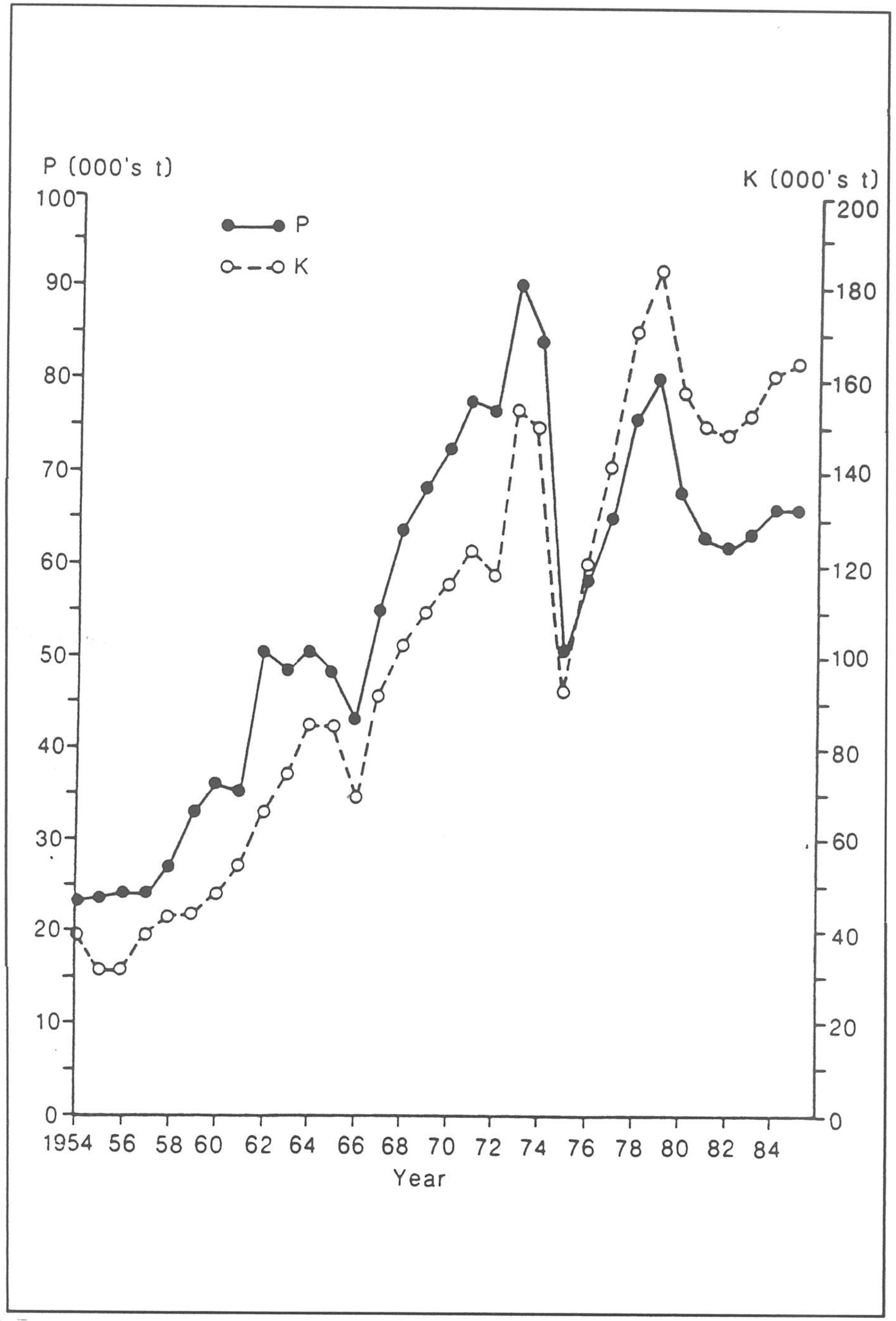

Figure 2 – Trends in phosphorus and potassium fertilizer use.

from the soil via the feed (predominantly grass or silage) and is recycled back to the soil, with the phosphorus in animal produce (milk and meat) having been removed from the system.

Some of the phosphorus in animal products is recycled to agricultural land in the wastes from the food processing industry. If this is taken into account it would increase the total input. There are other inputs in the form of atmospheric deposition, detergents used in agriculture and pesticides that probably account for a total of less than 3,000 T phosphorus per annum.

A balance sheet approach to inputs and outputs is relatively more straight forward in a country like Ireland where more than 90% of the utilised agricultural area is devoted to grassland.

There are many approximations and limitations involved in a balance of this scale. However, there can be little doubt that the total phosphorus inputs to Irish agriculture are more than double the outputs and that soil status will continue to increase while this situation prevails.

6. Reason for positive balance

There are a number of reasons that may explain the higher inputs relative to outputs. Many of the studies on crop response to phosphorus fertilizer were carried out in the 1940's and 1950's on very deficient soils where the need is higher than on soils with good phosphorus status. Fertilizer recommendations are based on rates for intensive agricultural production and these rates have been used on farms with much lower levels of production.

Many farms apply the crop needs as chemical fertilizer and put on extra in animal manures. In Ireland the total phosphorus in animal manures is of the same order as the total applied in chemical fertilizers with about 95% coming from grazing animals and about 5% from pigs and poultry. The efficient recycling of animal manures is therefore of major importance and phosphorus in manures should be taken into account when calculating the correct rate.

There has been a very close relationship between potassium and phosphorus fertilizer use. This relationship is illustrated in figure 2, which shows that the potassium has been generally about double the phosphorus rate. The reason for this is of course the fact that farmers have for many years used mainly 0.10.20 (% N,P,K) and 0.7.30 compound fertilizers particularly on grassland. This pattern has started to change in recent years with the increased use of high nitrogen compounds and also more recently compounds that contain nitrogen with only potassium or phosphorus.

7. Phosphorus loss to water

The correction of the deficiency of phosphorus in Irish soils has been one of the most important agricultural developments this century.

The continuing build up in soil status may be seen as a positive development increasing the capital value of the soil. For example, soil with reserves of 500 kg phosphorus per ha is worth about 500 IR pounds per ha more than a soil that has been depleted.

The most important concern is the increased awareness of the role of phosphorus in eutrophication. The loss of phosphorus to water can encourage excessive growth of algae and other plants in water. There has been an increased incidence of eutrophication in Ireland in recent years, particularly in our inland lakes.

Phosphorus from domestic source has been identified as an important factor, however it is usually possible to control with the use of suitable sewage treatment plants.

The loss from agriculture is also important and can be an important factor in eutrophication. Loss from agriculture is more difficult to control.

The phosphorus loss from agriculture to water was estimated at 500 T per year in 1953 (Walsh et al. 1957). The present loss is proably more than four times higher.

The average loss in 1950 was probably less than 0.1 kg of water soluble phosphorus per ha and now is probably over 0.3 kg per ha. It is likely that the loss is continuing to increase. It is therefore apparent that the high fertilizer use and increasing soil status is contributing to loss to water.

Mineral soils are generally very effective at retaining applied phosphorus. Clay soils are more effective at retention than light sandy soils and, on peat soils, most of the phosphorus not taken up by the crop will be readily leached into the water.

The phosphorus content of a number of Irish rivers is summarized in table 2. The values in table 2, with the exception of the river Lee are based on a report by Toner and McGarrigle (1989).

Table 2: **Estimate of average water soluble phosphorus export to rivers in 1986 (Lee in 1988) and the corresponding content in water.**

River	Export kg P/ha	Water mg P/m³	mm water to river from catchment
Barrow	.33	72	457
Boyne	.35	55	631
Lee	.45	44	1022
Nore	.36	57	626
Slaney	.30	42	715
Suir	.43	67	638
Mean	.37	56	682

Table 2 indicates that the annual average soluble phosphorus in river water is about three times the level considered limiting for eutrophication (Vollenweider, 1975). It is likely that if there were lakes or reservoirs on the rivers, listed above, eutrophication problems would develop.

The sampling points for the river meant that they were mainly from rural areas, this is particularly, true for the Lee and the Slaney and therefore most of the loss can be attributed to agriculture.

On grassland the applied phosphorus accumulates near the soil surface and may lead to relatively high levels in runoff water. Several kg of phosphorus per ha can be lost if runoff occurs shortly after Slurry spreading (Sherwood, 1986). It is clear that

eutrophication of water is very sensitive to phosphorus loss. Direct flow of manures to water is very serious in terms of phosphorus loading and must be avoided at all cost.

Soil sediment is also lost to water and contains phosphorus. The contribution from soil sediment to water depends on the status of the soil and the content in the water. If the soil status is low, it may reduce the phosphorus content of water by absorption, on the other hand if the soil status is high, it may enrich water by desorption.

8. Conclusions

There is strong evidence that more phosphorus fertilizer is being used than is necessary, to maintain soil fertility at an adequate level. This statement is supported by the continuing increase in the average soil phosphorus test and the fact that imports are more than double outputs. An ongoing positive phosphorus balance undoubtedly has important implications for both agricultural production and for water quality.

On the positive side a high status ensures that agricultural production is not limited by deficiency and ensures reserves against increase in price or shortage in the future.

On the other hand too high status can contribute to nutrient imbalance with induced deficiencies or increased requirements for nutrients such as zinc and sulphur. Higher use than necessary represents an increased cost to agriculture. Imported phosphorus costs more than 60 million Irish pounds per year.

There is very little information on the relationship between soil phosphorus status and loss to water. It is reasonable to assume that as status increases that loss to water will also increase.

Phosphorus use in Ireland is not high by the standards of other EEC countries. There is evidence that the soil status in the U.K. is increasing while the fertilizer use has not increased significantly over the past 30 years (Church and Skinner, 1986). In the European Community the lowest fertilizer use is in Greece, Portugal and Spain with an average of about 7 kg phosphorus per ha per annum on the utilised agricultural area. Ireland and the U.K. are next at 11 and the other 7 countries use between 17 and 27 kg per ha per year. It is possible that a positive phosphorus balance may be widespread.

From an environmental point of view it is important that excess application of fertilizer phosphorus should be avoided. The rate should be as low as possible so that it is compatible with good agricultural production and good water quality.

It is an important challenge facing agriculture now to ensure that phosphorus inputs more closely match outputs. It may be desirable, where appropriate, to use fertilizer phosphates with low water solubility to replace the traditional super phosphates in order to minimise loss to water.

Figure 3 summarizes the trends in fertilizer phosphorus use in Ireland in the 20th century. The values for the first half of the century are taken from a paper by Dr. Tom Walsh and his colleagues (Walsh, et al. 1957). It reflects many of the changing fortunes of agriculture over that time. Figure 3 speculates on two possible alternatives for the last ten years of the century. If the rate of decrease over recent years continue, inputs and outputs would be near equal by the year 2010. A more rapid decrease will be necessary if equality is to be reached by the year 2000.

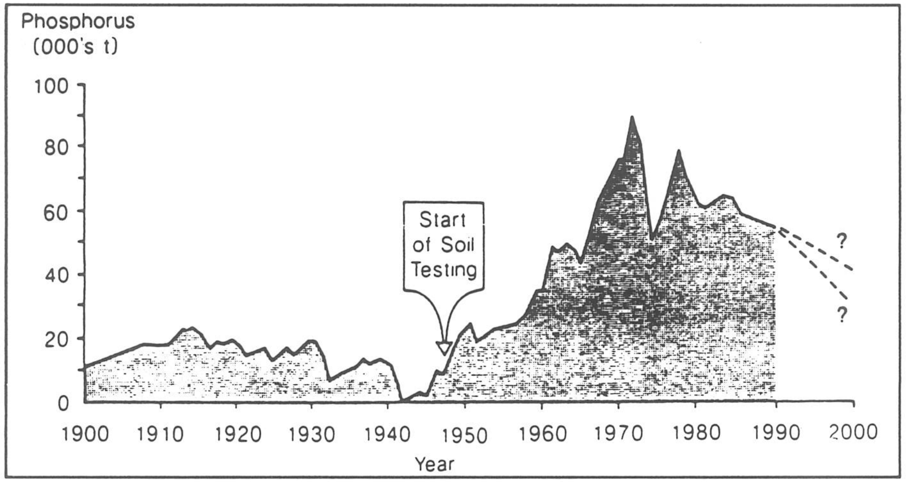

Figure 3 – A century of phosphorus fertilizer use.

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