Institute of Hydrology

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Natural Environment Research Council

THE EFFECTS OF AGRICULTURAL PRACTICES
ON THE DISCHARGE FROM A LOWLAND CATCHMENT.

AN INTERIM REPORT ON A JOINT IH/ADAS STUDY
AT MILTON KEYNES, BUCKINGHAMSHIRE

Please !!!

THE EFFECTS OF AGRICULTURAL PRACTICES ON THE DISCHARGE FROM A LOWLAND CATCHMENT

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Introduction

The need to increase production of home-grown foodstuffs in order to reduce the country's imported food bill has led to an intensification in farming practices. In particular, the use of inorganic fertilizers has increased dramatically. These fertilizers supply three essential nutrients required for plant growth, ie nitrogen, phosphorus, and potassium, and are used to supplement the supply of "natural" nutrients to the soil in rainfall and animal manures. There is also a great deal of nutrient release during cultivation but this, together with the supply of "natural" nutrients is inadequate to satisfy the needs of modern crops and grass species.

At the same time, a great deal of concern is being expressed by the water industry about the concentrations of nitrogen, especially in the nitrate form, occurring in streams, and the high cost of reducing these to an acceptable limit in drinking water. Nitrate nitrogen is the oxidized and most soluble form of nitrogen and is readily taken up by plants during the growing season. Any excess is easily leached out of the soil by rainwater and it is possible that the intensification in farming methods and the increased use of inorganic fertilizers may result in increasing concentrations in streams. This is particularly important in the highly populated, intensively cultivated lowland areas where the nitrate concentrations in streams are likely to be relatively high.

Objectives

The objectives of this study are:-

(i) to determine stream nitrate concentrations and their seasonal variation and to investigate the extent to which these can be related to agricultural practices,

and (ii) to determine nitrogen inputs to and outputs from a lowland catchment area in order that a nitrogen balance be carried out.

Catchment Description

The area chosen for the study is a small (170 hectare) clay catchment at Shenley Brook End near Milton Keynes new town, Buckinghamshire. Aerial surveys of the catchment show that it is composed of 11% woodland, 23% arable land, and 66% grassland. The woodland consists of mature deciduous trees, mostly in one large block, Howe Park Wood. The arable land is used almost entirely for cereal growing, and the cereal area is approximately equally divided into winter wheat and spring barley crops. In 1978 two fields were used for growing turnips; these were later grazed by sheep. Part of the grassland is grazed by dairy cows but the greater part is used for sheep grazing and for the production of hay or silage. The dairy farm grassland is intensively managed but some of the other grassland receives relatively small amounts of fertilizers.

The Soil Survey of England and Wales mapped the soils of the catchment in the spring of 1979. Seven soil series were recognised; these are listed below with an indication of their relative abundance in the catchment.

Soil Series	Parent material	Approximate percentage area of catchment
Hanslope	Chalky boulder clay	25
Ragdale	Chalky boulder clay (decalcified in the soil profile)	50
Beccles	Chalky boulder clay	
Ashley	Chalky boulder clay	
Rowsham	Valley bottom head	
Lawford	Valley bottom head	2
Horseley	Fluvioglacial drift	13

These are all heavy soils with a clay loam or similar texture. The upstream half of the catchment is almost entirely Ragdale or Hanslope series but the rest of the catchment is more variable.

Data Collection

The catchment has been fully instrumented to measure discharge, rainfall and the meteorological variables, and data since March 1972 are available. These show five year annual average totals of 603 mm preciptation, 160 mm discharge (26.5% of rainfall), and 576 mm potential evapotranspiration. On average streamflow ceases for 5 months each summer.

Two North Hants automatic liquid samplers were installed during December 1977. One abstracts a sample of water from the stream every eight hours when the stream is flowing. The other, which is triggered by a rising water level, abstracts a sample every 30 minutes during those periods of special interest, ie high flow rates, storms following hot dry periods, etc. The water samples are taken to MAFF, Reading, for chemical analysis to determine the concentrations of nitrate-N and weekly average concentrations of ammonium-N, phosphorus, potassium, magnesium, and calcium. A rainfall collector was installed in February 1979. The rainwater it collects is analysed for ammonium-N, nitrate-N, total organic-N, phosphorus, and potassium.

In July 1978 a scheme was initiated whereby all the farmers having land on the catchment would be visited and asked what crops they had grown and what fertilizers and manures they had used on each field during the year. This information is noted on a land management form (see Figure 1). From this information it is possible to estimate nitrogen inputs to the catchment in the form of fertilisers and manures. It is also possible to assess any changes in land use which may affect the nitrogen balance, eg ploughing of grassland which may affect the release of nitrate-N from the soil. It is also hoped to use the information on the form to estimate nitrogen uptakes by crops and animals and the return of nitrogen in animal manures. The farmers were also asked if there were artificial drainage systems in their fields and, if so, a note was made of the direction of drain flow and the likely efficiency of the system. It is hoped that such information be collected every year for the duration of the project.

Data Processing

The results of the chemical analyses carried out on the streamflow samples will be studied to determine the extent to which relationships between variations in nitrate-N concentrations and rainfall distribution, flow levels, temperature, season and agricultural practices within the catchment can be identified. It will also be possible to quantify accurately three terms in the nitrogen balance of the catchment; namely total input in rainfall (given as total rainfall multiplied by the total nitrogen concentration in the rainwater), total input in fertilizer additions, and total output in streamflow (given as the sum of discharge multiplied by the nitrogen concentration in the stream water). In addition estimates of the nitrogen inputs in imported manures and of the off take in agricultural produce will be possible. Thus some estimate of the magnitude of the remaining terms in the balance will be feasible.

Nitrate Concentrations

Inspection of the results of the chemical analyses carried out on the samples from the stream indicate that nitrate-nitrogen is the dominant form of nitrogen in the water. In fact the concentration of ammonium-nitrogen is usually below the lowest detectable limit of 0.02 mg/l. It has been decided therefore to consider only the nitrate form of nitrogen in the catchment discharge.

Nitrate concentrations (mg/l) and daily rainfall (mm) are shown on a time series basis in Figures 2 and 3 for 1978 and the first six months of 1979 respectively. In 1978 flow ceased at the end of May and resumed in December. In 1979 flow ceased at the end of July. The trends in the concentration values are similar for the two years showing high concentrations when flow resumes in the winter with a gradual decrease until May or June when higher concentrations are again observed.

Nitrogen Balance

The various components of the nitrogen balance being considered in this study are shown in Figure 4.

Nitrogen inputs into the catchment are calculated as the product of the rainfall totals and total nitrogen concentrations over the various time intervals during which rainfall samples were collected. The nitrogen losses in the stream are calculated in a similar manner as the product of discharge totals and nitrate concentrations. Inputs in fertilizers and manures and outputs in crop and animal offtakes are estimated from the information given by the various farmers on the land management form (Figure 1). This leaves three unknowns; changes in soil nitrogen, inputs in fixation, and outputs in gaseous losses notably denitrification. The most convenient time interval over which such a balance can be carried out is one year. In this case it can be assumed that the changes in soil nitrogen will be small and may be neglected. This means that the balance will give an estimate of the difference between denitrification and nitrogen fixation on an annual basis.

It is important when carrying out such an annual balance to ensure that the correct time periods are used, ie to ensure that any losses are attributed to the correct inputs. This is particularly so in the case of fertilizer and manure applications as there will be a time lag before any leaching losses are detected in the discharge. Inspection of the nitrate concentrations plotted for 1978 and 1979 in Figures 2 and 3 show that, in both cases, the concentrations fell during the early months of the year and then started rising again in late spring or early summer. This, presumably, reflects the fertilizers and manures applied during the spring sowing. If this is the case, these increases in concentration would be obvious points at which to start and end the annual nitrogen balance. Figure 5 shows the various components of the nitrogen balance and the time periods over which they are relevant for 1978/9 when carrying out the balance, only inputs to and outputs from the catchment are considered; eg in the case of manure and slurry applications, only imported manures are considered.

The various components of the balance are currently being evaluated.

MINISTRY OF AGRICULTURE, FISHERIES AND FOOD

AGRICULTURAL DEVELOPMENT AND ADVISORY SERVICE

SHENLEY BROOK CATCHMENT STUDY

NAME AND ADDRESS

HOLDING NO.

Field OS No. and Area

	1977	1978	
Crop			Please indicate amounts and month of application
Fertilizers (N,P and K)			
FYM			
Slurry			
If Grass how utilized?			
If grazed, estimated number of grazing days, in the whole season for:-			
dairy cows			
other cattle			
ewes			
lambs			
horses			
other (please specify)			
Drainage			

FIG. 1 LAND MANAGEMENT FORM

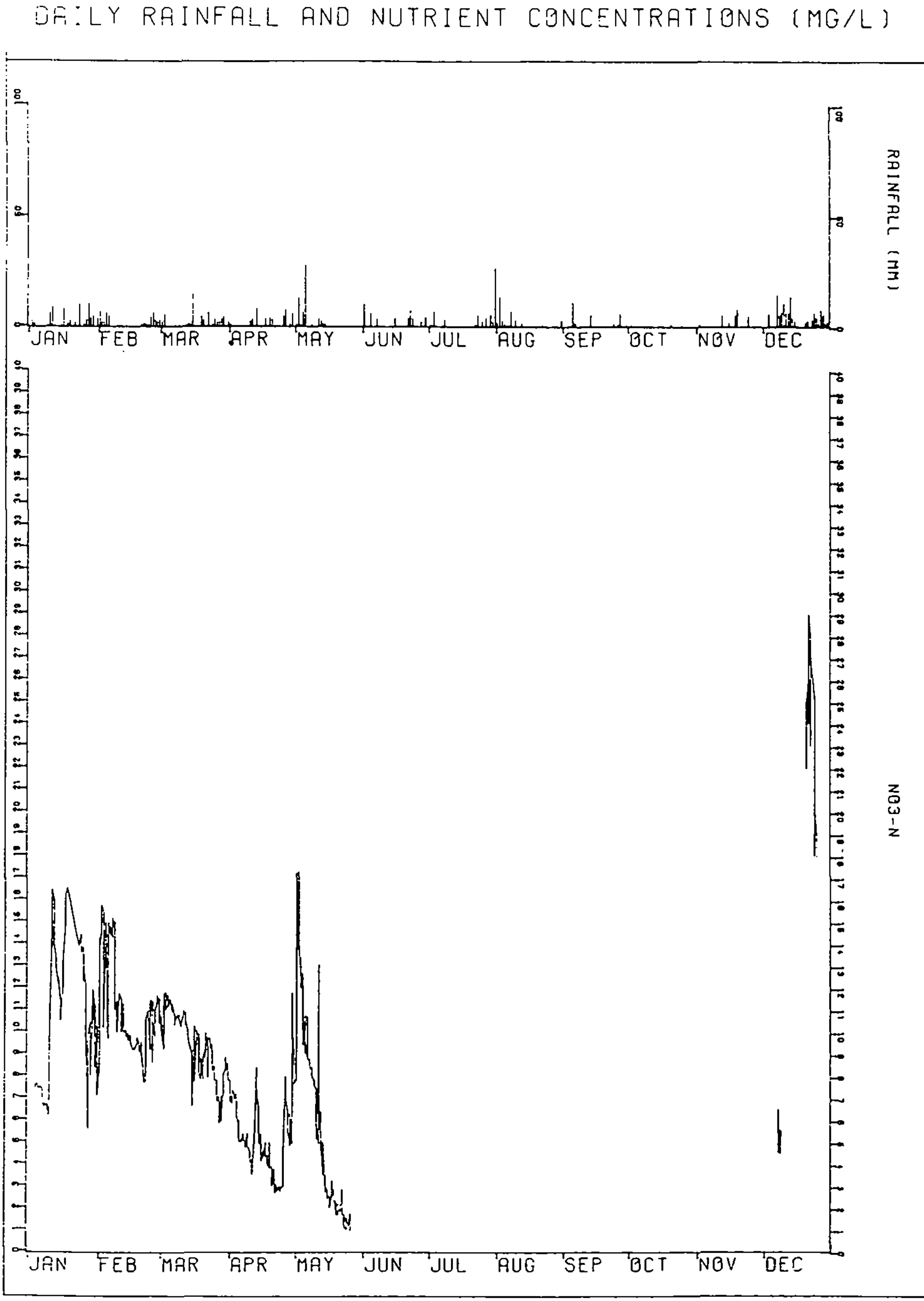

FIG. 2 NITRATE CONCENTRATION IN THE DISCHARGE FROM SHENLEY FOR 1978

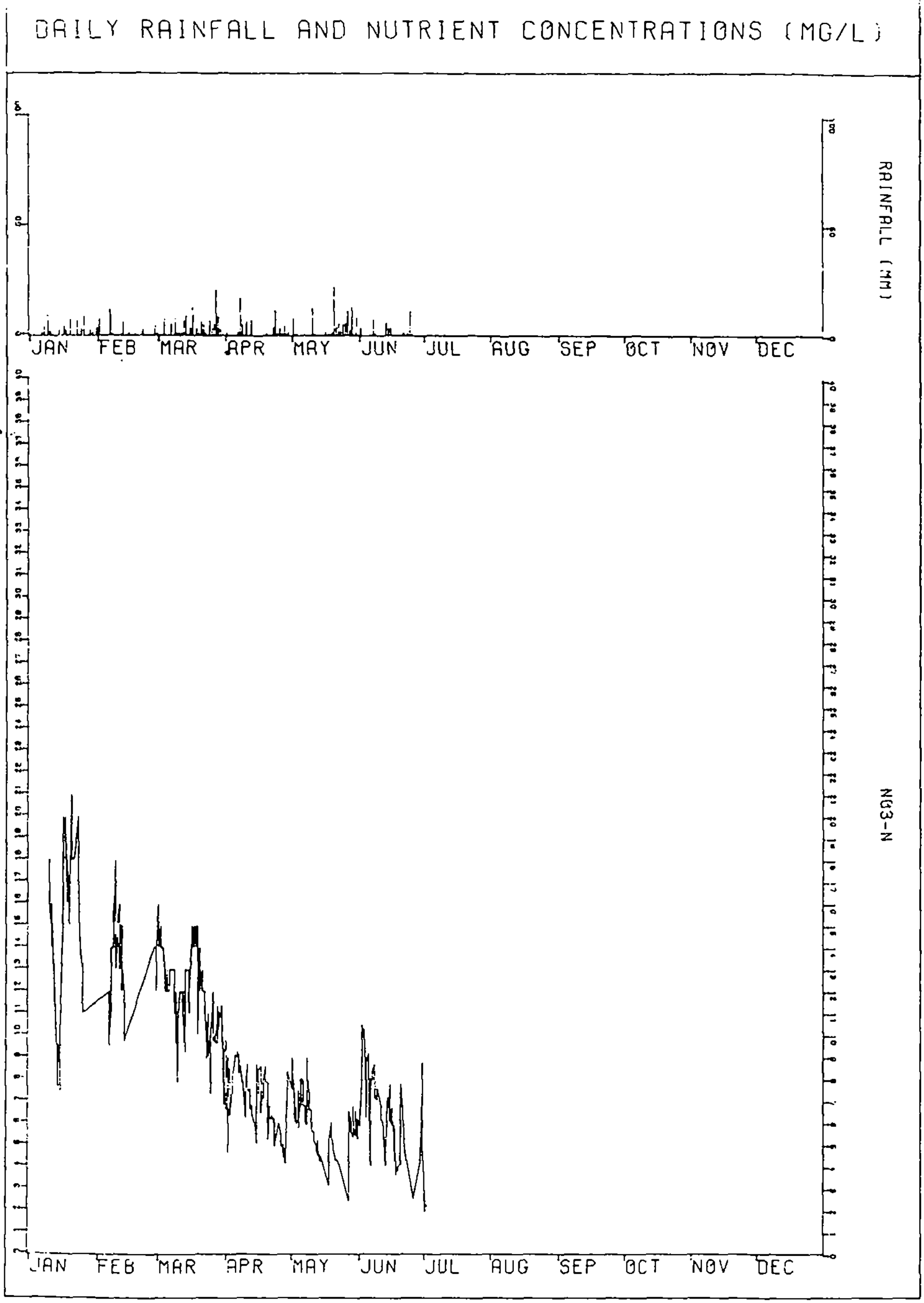

FIG. 3 NITRATE CONCENTRATION IN THE DISCHARGE FROM SHENLEY FOR 1979

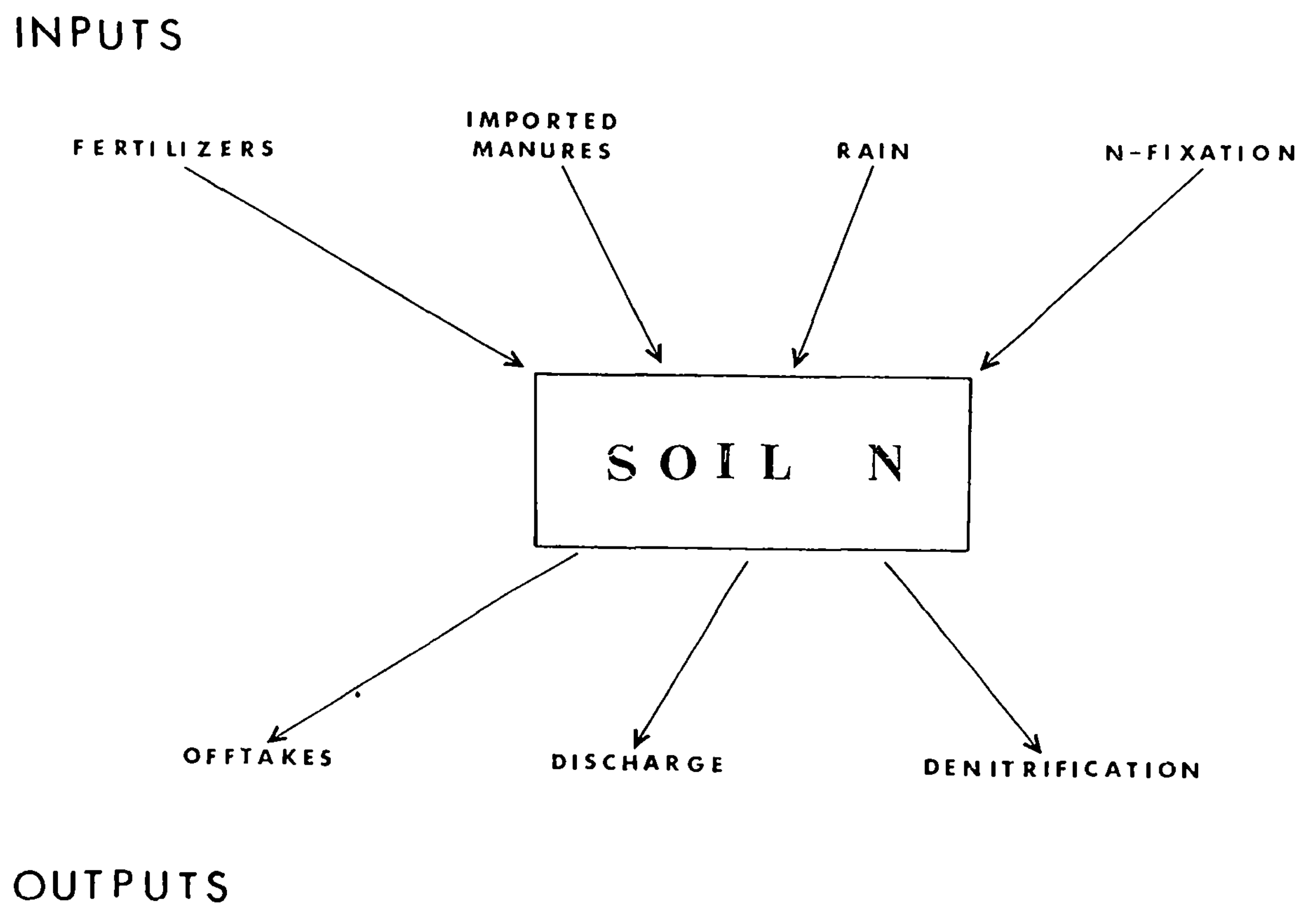

Fig 4 The Components of the Nitrogen Balance

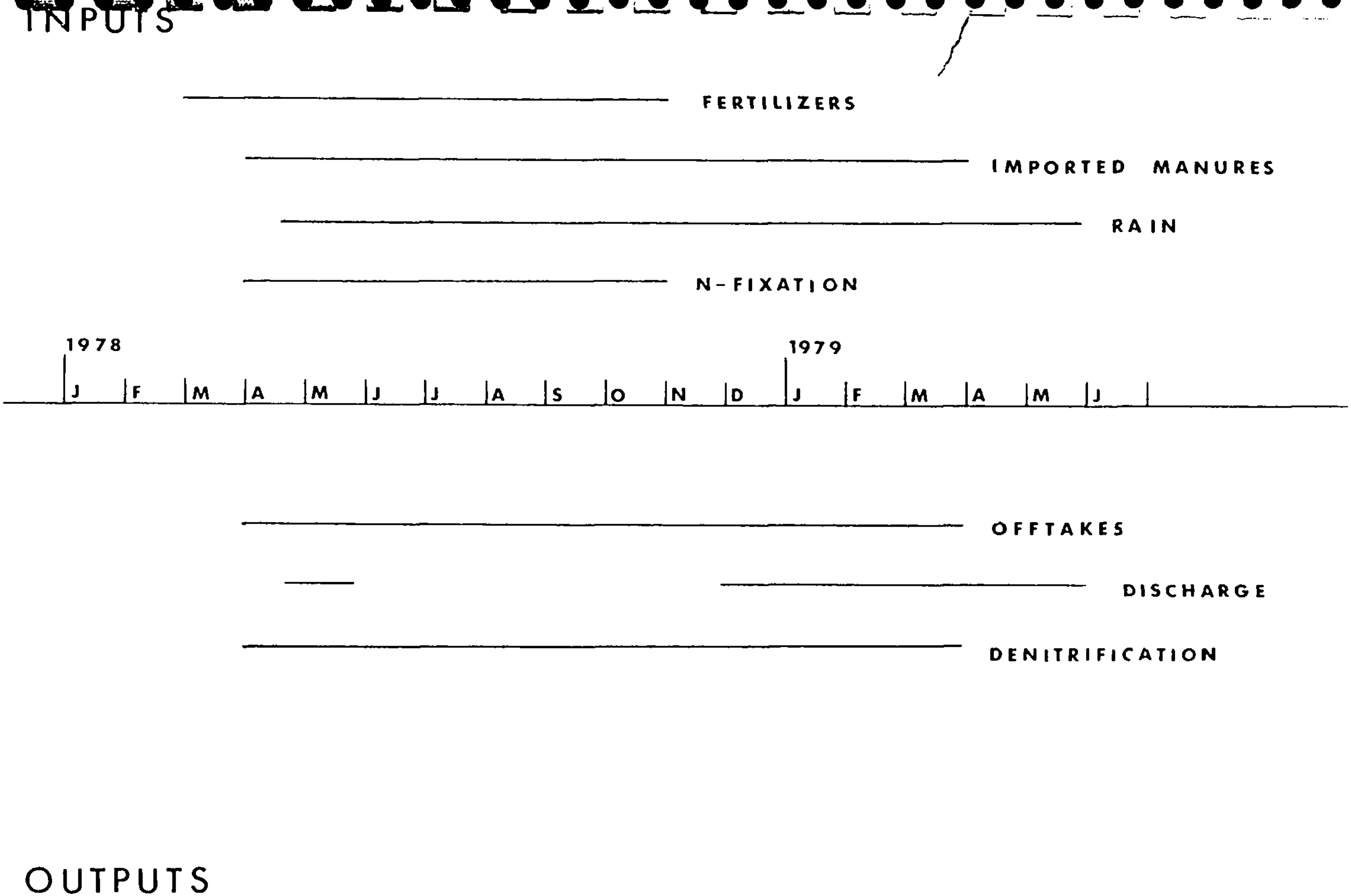

Fig 5 The Nitrogen Balance 1978/9