

Fertiliser Series No. 13 Removal by crops and PK balance sheets

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Maintenance of soil fertility, in terms of nutrient status, depends on achieving a balance between nutrient removal (offtake) by crops and application (input) of fertilisers and animal manures. Provided that reliable estimates of inputs and offtakes can be made, a simple **Balance Sheet** can be drawn up for any particular crop rotation. This approach is particularly useful for managing the Phosphate (P) and Potash (K) status of the soil.

A balance sheet can only be drawn up if the inputs and offtakes can be reliably measured or estimated with no substantial leakage from the soil/crop system. This is possible for P and K because minimal amounts are lost from the soil by means other than crop offtake. Nitrogen (N), can not be managed in this way because of large, unpredictable, losses in drainage water and gaseous emissions.

All plant nutrients are present in the soil in a variety of chemical forms. Usually, only a small fraction of the total is readily available to the growing crop and there is a steady process of exchange between available and less available chemical forms. For P and K these processes are reasonably predictable and tend to be in equilibrium. Soil analysis can measure the readily available P and K in a soil and, provided that nutrient inputs and offtakes have been balanced, there will be little unpredictable change in P or K status after 5-7 years.

Conversions of nitrogen between available and less available forms, are controlled by microbiological activity, and are both rapid and unpredictable. This is a further reason for the unsuitability of a balance sheet approach for N and explains the poor performance of soil analysis as a predictor of crop N requirement. The other major elements in crop nutrition, calcium, magnesium and sulphur do not generally require annual maintenance applications.

Calcium is normally replenished by periodic dressings of limestone in the normal course of soil pH maintenance. Magnesium levels in soil are usually maintained by the use of magnesian (Dolomitic) limestone as an alternative to standard (calcium carbonate) limestone.

Sulphur (S) reserves may be low on sandy, low organic matter soils. In these circumstances, added S can rapidly leach from the soil and a balance sheet approach for S, like nitrogen, is of little value. Heavier textured soils and those with moderate to high organic matter content generally have substantial S reserves and require only periodic monitoring of soil status. N.B. Such monitoring is

becoming increasingly important as S is absent from most modern fertilisers and inputs of atmospheric S are rapidly decreasing.

For details of materials and strategies for maintaining adequate supplies of calcium, magnesium and sulphur consult SAC Technical Notes:

Liming Materials	T95 Fertiliser Series No.20
Magnesium in Soils & Crops	T92 Fertiliser Series No.18
Sulphur in Soils, Fertilisers and Crops	T160 Fertiliser Series No.19

A balance sheet approach to trace element management is rarely applicable and a combination of routine soil or plant analysis and observation of visual symptoms is recommended.

CREATING A PK BALANCE SHEET

There are three basic requirements:

1. Defining a target for soil PK status.
2. Calculating manure and fertiliser PK inputs.
3. Calculating crop PK offtakes

1. DEFINING TARGETS for Soil P and K Status

In theory, and under ideal conditions, all of the crops P and K can be supplied by 'bag' fertiliser with no contribution from the soil. In practice yield levels are higher when substantial amounts of available P and K are distributed through the soil profile, particularly under stress (Eg. drought) conditions. An impoverished soil will also absorb fertiliser P (and possibly K), rendering them less effective to the crop.

In general grass is most effective in extracting P and K from soils and tolerates relatively low PK status. Potatoes, swedes and most horticultural vegetables require a relatively

high PK status. Cereals are intermediate in their requirements.

Consequently the TARGET STATUS depends on the crop rotation.

Crops in rotation	Target Status (soil analysis, mg/l)	
	Phosphate	Potash
Grass (moderate/high N)	Moderate* (6)	Low-Mod (80)
Grass/Clover	Moderate (9)	Moderate(100)
Ley/Forage/Cereals	Mod-High(14)	Moderate(120)
Cereals/Oilseed rape	Mod-High(14)	Moderate(120)
Cereals/potatoes/vegetables	High (18)	Moderate(150)

*N.B. The moderate range is rather wide for this purpose, 4.5-13.0 and 75-200 for soil P and K status respectively. SAC soil analysis reports provide the required numerical values in addition to the wide verbal description.

These targets assume a loam, sandy loam or sandy clay loam soil, typical of the more productive soils of Scotland.

On the heavier clay soils a lower target for P may be more realistic whereas the target levels for K should be more easily achieved. On sands and some loamy sands a relatively high P status is readily achieved but a K status of 120-150 may not be possible. This is because of the low capacity of these soils to retain K, any excess may be lost in drainage water.

Bearing in mind the current economic conditions, the following general guide-lines should be followed:

For soils of low or very low status do not attempt to raise status very quickly, it will be a number of years before the investment pays off. Aim to apply 30-40 kg (24-32 units/acre) P_2O_5 or K_2O in excess of offtake, or as much as is affordable.

For soils at or about the target level, balance inputs with offtake.

For soils which are above the target levels, savings can and should be made. In general inputs should only be reduced by 20-30 kg/ha/year (16-24 units/acre/year) below the crop offtake.

Recently there have been suggestions, from a number of sources, that P and K can be applied every second or third year. This, so called, rotational manuring is not unconditionally recommended by SAC. The practice is possible on many soils which have a P or K status at or above the target values and money can be saved on application costs. However, the practice is not recommended on all soils and SAC advice should be sought,

2. CALCULATING INPUTS

Manures and Slurries

These are very variable products, calculation of average nutrient contents and the sources of variability are described in the Technical Note "Fertiliser allowances for manures and slurries" Fertiliser Series No. 14. (T309). N.B. the composition of these organic manures is given in terms of AVAILABLE and TOTAL nutrient contents.

AVAILABLE nutrient content is only that part of total which is available to the first crop grown after application.

TOTAL nutrient content includes the nutrients which will be released over a longer period, to raise or maintain soil status. FOR THE PURPOSES OF PK BALANCE SHEETS USE THE TOTAL CONTENTS OF P_2O_5 AND K_2O .

A farm with a substantial animal unit will be able to make large savings in the annual fertiliser bill. Fifty dairy cows will produce P_2O_5 and K_2O worth over £800 in a 6 month housed period.

Inorganic Fertilisers

The P_2O_5 and K_2O contribution from fertiliser is easily calculated from the analysis stated on the bag.

For example, a 0 : 24 : 24 fertiliser contains:

Imperial System.

Multiply weight of fertiliser (in cwt.) by 24.

P_2O_5 (and K_2O) content per 1 cwt. bag = 24 units

3 bags contain $3 \times 24 = 72$ units

1 ton (20 cwt) contains $20 \times 24 = 480$ units

Metric System.

Multiply weight of fertiliser (in kg) by 24 and divide by 100.

(for 50kg bags this is equal to $24 \times 1/2$)

P_2O_5 (and K_2O) content per 50kg bag = $50 \times 24/100$

(or $24 \times 1/2$)

= 12 kg

3 bags contain $3 \times 24 \times 1/2 = 36$ kg

1 tonne contains $1000 \times 24/100 = 240$ kg

3. CALCULATING OFFTAKES (NUTRIENT REMOVAL)

The quantity of nutrients removed by crops is calculated from the crop yield and composition. assuming that a reasonable estimate of yield is available, the P and K content is sufficiently predictable to allow offtakes to be calculated with confidence. The data in Table 1 provides the offtakes in kg/tonne (and units/ton) of materials at typical moisture contents. The table is divided into 2 parts: 'A' is based on Scottish data, part 'B' covers crops for which there is little Scottish data and is based on other UK sources.

Example: A 50 t/ha (20 t/acre) potato crop will remove:

0.9 kg/tonne of P_2O_5 (1.8 units/ton)

and 5.0 kg/tonne of K_2O (10 units/ton)

Multiplying 50 (tonnes) by 0.9 and 5.0 gives the amount removed: 45 kg P_2O_5 and 250 kg K_2O /ha (or multiplying 20 (tons) by 1.8 and 10.0 gives the amount removed: 36 units P_2O_5 and 200 units K_2O /acre.)

Table 1. P and K removal by crops, kg/t and units/ton of fresh¹ material

(A) Crop	kg/tonne		units/ton	
	P ₂ O ₅	K ₂ O	P ₂ O ₅	K ₂ O
Spring Cereals				
Grain	7.8	5.6	15.6	11.2
Straw	1.5	12.6	3.0	25.2
Grain+straw ²	8.8	13.8	17.6	27.6
Winter Cereals				
Grain	7.8	5.6	15.6	11.2
Straw	1.3	9.3	2.6	18.6
Grain+straw ²	8.6	11.6	17.2	23.2
Oilseed Rape				
Grain	12.5	7.5	25.0	15.0
Straw	2.2	13.0	4.4	26.0
Grain+straw ³	13.6	14.0	27.2	28.0
Potatoes	0.9	5.0	1.8	10.0
Carrots	0.6	3.5	1.2	7.0
Swede roots	0.7	2.0	1.4	4.0
Swede tops	1.0	4.0	2.0	8.0
Grass				
Silage stage	1.4	4.8	2.8	9.6
Hay (made)	4.8	16.0	9.6	32.0
 (B)				
Dried Peas	8.8	10.0	17.6	20.0
Vining Peas	1.7	3.2	3.4	6.4
Field Beans	11.0	12.0	22.0	24.0
Onion	0.7	1.9	1.4	3.8
Brussel Sprouts	2.1	6.9	4.2	13.8
Cauliflower	1.4	4.6	2.8	9.2
Cabbage	0.9	3.7	1.8	7.4
Forage Maize	1.1	3.6	2.2	7.2
Kale	1.1	4.6	2.2	9.2
Forage Rape	1.4	4.8	2.8	9.6
Turnips	0.7	2.9	1.4	5.8
Fodder Beet Roots	0.7	2.5	1.4	5.0
Fodder Beet Tops	1.0	5.5	2.0	11.0

- Notes:**
1. Weight of crop fresh material refers to the weight at normal harvested moisture contents. Eg. at 15% moisture for cereals.
 2. Grain + straw refers to 1.0t of grain PLUS 0.65t of straw. Straw weights are seldom recorded accurately but the grain: straw ratio is a reliable basis for calculation. **WHEN STRAW IS NOT REMOVED** (burned or ploughed under), use the grain figures only.
 3. Oilseed rape straw is sometimes removed for bedding. The straw tends to shatter during combining/baling and about 0.5t of straw is expected to be removed for each 1.0t of seed.

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