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NOTA DE INVESTIGACIÓN

PHOSPHATIC FERTILISER GUIDELINES FOR GRAZING PERMANENT PASTURES

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SUMMARY

Phosphorus is an essential element for plant and animal growth. While productive agriculture is not possible on soils with very low soil P, there is increasing evidence that high soil P can lead to leakage of P from agricultural systems to water bodies. In this paper the guidelines are drawn up for application of P to grazed grassland. The guidelines are aimed at ensuring the optimum yields with minimum P inputs. The P fertiliser strategy is based on three principles. The first is to achieve a soil P status that ensures optimum production. For intensive agriculture, the P status required is between 6.1 and 10.0 mg P/l of soil (Morgan's extractant). For more extensive farming systems a soil P of between 3.1 and 6.0 mg P/l is adequate. Once this P status is achieved, the second principle is that phosphorus is used to replace P removed by the farming system. At stocking rates of 2.0-2.5 cows/ha, maintenance dressings for dairying range are from ten to twenty kg P/ha, respectively depending on milk yields. The third principle is that soil P status needs to be checked every three to four years in order to ensure the fertiliser strategy employed is correct.

Key words: Dairy systems, beef systems

INTRODUCTION

Phosphorus is an essential element for healthy plant and animal growth. In agricultural systems P is needed for seed and root formation and the accumulation and release of energy during cellular metabolism (Finkl and Simonsson, 1979). In animals, P is required for bone formation and a deficiency can cause osteomatacea. 'Pica' or depraved appetite has been noted in cattle when there is a severe deficiency of P in the diet. Low dietary P may be associated with poor fertility, and apparent dysfunction of the ovaries causing inhibition, or irregularity of oestrus (Culleton and Murphy, 1998).

When soil P levels are low, there is little scope for improvements in productivity.

Conway *et al.* (1972), in a study using old permanent pasture for sheep and cattle production, showed that when P was applied to an impoverished soil over a four year period, and improved management strategies implemented that the stocking rate of cattle and sheep could be increased four-fold, over a four year period. Culleton (1989) reported similar findings and he attributed the increase in productivity to increases in *Lolium perenne* content in the sward. A long term grazing trial at Johnstown Castle in South-East Ireland also clearly demonstrated that in low soil P situations, the *Lolium perenne* content of the sward declined, and as the soil P levels increased, so too did L. *perenne* content (Culleton *et al.*, 1998).

The usage of P fertiliser to achieve optimum crop production and improve soil fertility has been a cornerstone of agricultural policy in Ireland. Fertiliser use increased from 16 000 in the middle of this century to approximately 60 000 tonnes during most of the 1990's. This resulted in large increases in soil P levels and in 1998, the mean soil P levels of the 50 000 soil samples analysed at Johnstown Castle was 8 mg/l (Culleton *et al.*, 1999), with some 20% of samples with P levels above what is required for optimum grassland production.

Agronomically, this soil phosphorus is a valuable capital asset. However, Tunney (1990) drew up a P balance sheet for the country and estimated that there was 60% more P being spread than was being removed. Total annual P inputs were 77 296 t and total P outputs were 31 255 tonnes. This annual surplus had lead to the increased soil P levels that is now so clearly evident.

Eurtrophication is responsible for the deterioration in fresh water quality in Ireland. Phosphorus is considered to be one of the main causes of eutrophication in fresh water. The Irish Environment Protection Agency has indicated that agriculture accounts for about half of the deterioration of our water quality. Tunney *et al.* (1999) found a positive relationship between soil P levels and the P in water. In further studies Tunney *et al.* (2000) found a good relationship between soil test phosphorus and molybdate reactive phosphate, for grassland sites that do not have inputs from farmyards or other point sources. Sibbesen and Sharply (1997) reported similar relationships i.e. as soil P levels rose so too did P levels in water.

Against this background the fertiliser phosphorus guidelines for grazed grassland were reviewed and new recommendations were issued. The objective of these guidelines is to define the minimum amounts of phosphorus needed to ensure optimum yield while at the same time protecting the environment.

GUIDELINES

The new guidelines were based on three principles

(1) Defining the optimum soil phosphorus status, for production.

(2) Adapting a strategy for P application rates.

(3) Monitoring soil P status.

The extractant used for determining plant available phosphorus in Ireland is Morgan's and the methods used is as outlined by Byrne (1979).

(1) Defining the optimum soil P status for production.

When soils are analysed for nutrient status, an index system is used to categorise them into different soil P levels. This index system is presented in Table 1. Agricultural productivity is very low when soils are in Index 1 (Conway *et al.*, 1972), while at Index 4, P levels are very high and there is no agronomic response to further phosphorus fertiliser (Herlihy *et al.*, 1996). The aim of agricultural productivity is to have soils at Index 2 or Index 3.

TABLE 1

Soil phosphorus index system

Índices de fósforo en el suelo

Soil Index	Mineral soil P ranges (mg/l) (Morgan's extract)[1]	Crop response
1	0-3.0	Definite
2	3.1 - 6.0	Likely
3	6.1- 10	Unlikely
4	>10	None

[1]**Nota de la Dirección:**

En la España Húmeda se utiliza el método de Olsen para determinar el nivel de P en el suelo. Los intervalos (mg/l) correspondientes a los distintos índices serían: 1) 0-14,5; 2) 14,6-23,3) 23,4-34,9; 4) >34,9.

Herlihy *et al.* (1996) concluded that for optimum production under Irish conditions a soil phosphorus status of Index 3 is desirable. Recent work in Australia (Agriculture Victoria, 2000) support this view. This soil P status also ensures optimum grass growth at both ends of the grazing season (Murphy, 1977; Keeffe *et al.*, 1999).

There are situations when Index 3 levels are not required. Irish soils have been

classified in terms of their stock carrying capacity (Lee and Diamond, 1972) and many farmers are stocked below the potential of the soils. It is reasonable that soils can be maintained at Index 2 for this type of farming. Table 2 outlines the considerations that can be taken into account when deciding to opt for Index 2 or Index 3.

TABLE 2
Parameters for choosing your target P index.
Parámetros para elegir el índice objetivo

Index 2	Index 3
1. Stocking rate below 75% of stocking carrying capacity.	1. Stocking rate at or near stock carrying capacity
2. Set stocked paddocks.	2. Rotational grazing.
3. Out of season grazing not required.	3. Out of season grazing required

(2) Adopting a strategy for P application rates

The approach reported by Bertilsson and Forsberg (1997) for fertiliser P strategy has been adopted in Ireland. They indicated that when an adequate level of soil fertility is attained, optimum yields can be maintained by replacing the P that is removed from the farming system. Therefore, P is required to replace the nutrients exported off the farm in animal product and other losses from roadways etc.

The offtakes of P depend largely on farming system and stocking rates. Table 3 summarizes the amounts of P removed in dairy systems based on Agricultural Research Council data (ARC, 1988). Calculations are based on replacement rates of cull cows of

TABLE 3
Offtakes of phosphorus (kg/ha/year) in dairying
Consumo de fósforo (kg/ha/año) en fincas de vacuno de leche

Milk yield	Stocking rate (cows/ha)			
l/cow/year	1.5	2.0	2.5	3.0
4000	6.3	8.2	10.2	12.1
6000	9.1	12.0	14.9	17.8
8000	12.0	15.8	19.6	23.4
10000	14.8	19.5	24.3	29.1

20% and mean weight of cull cows and heifers of 500 kg. The P offtakes equals the P maintenance requirements.

When soil P status is below the target soil P levels required, extra P must be added over and above that required for maintenance. Tunney *et al.* (1996) suggested that an extra 10 kg P/ha should be added at each application in order to gradually increase the soil P status over a number of years.

The P guidelines for dairying with milk yields of 5000 L/year are summarised in Table 4. As stocking rate increases, the P removals increases and hence the P needed to

TABLE 4

Phosphorus guidelines (kg/ha) for intensive dairying

Recomendaciones de fósforo (P, kg/ha) en explotaciones intensivas de vacuno de leche

Soil index	Stocking rate (livestock units/ha)		
	1.6-2.0	2.1-2.5	2.5+
1	29	33	36
2	19	23	26
3	9	13	16
4	0	0	0

maintain soil P status also increases. Similarly, as milk yields increase, so to does the amounts of P removed and therefore more P is required.

The P removals in beef systems are significantly lower than those in dairying (ARC, 1988). The removals for two rates of liveweight gain are summarised for various stocking rates in Table 5. The P fertiliser guidelines based on these figures are summarised in Table 6.

TABLE 5

Phosphorus offtakes (kg/ha/year) in dry stock systems

Consumo de fósforo (kg/ha/año) en explotaciones de vacuno de carne

Liveweight gain	Stocking rate (livestock units/ha)			
	1.5	2.0	2.5	3.0
0.85 kg/day	4.0	5.9	8.0	11.0
0.70 kg/day	3.7	5.5	7.4	10.3

TABLE 6

Phosphorus guidelines (kg/ha) for intensive dry stock systems

Recomendaciones de fósforo (P, kg/ha) en explotaciones intensivas de vacuno de carne

Soil index	Stocking rate (livestock units/ha)		
	1.6-2.0	2.1-2.5	2.5+
1	25	27	29
2	15	17	19
3	5	7	9
4	0	0	0

(3) Monitoring Soil P Status

These guidelines are focused and quite precise, and will, if followed, ensure productive agriculture is possible with minimum P inputs. However, it is prudent to monitor the soil P status over the long term by frequent soil analysis. Rising soil P levels suggest that the guidelines are still too generous and further reductions can be made. On the other hand, reducing soil P levels suggest that too little P is being applied, and more P than was planned for, should be applied.

There is a significant body of research in the United States about the economics of production, and environmental quality as affected by soil testing methods and philosophies of making fertiliser recommendations (Eckert and McLean, 1981; Liebhardt, 1981; Olsen *et al.,* 1982). The American work has shown that the concept of sufficiency level is superior to the maintenance philosophy for farmers. The sufficiency level approach states that you test for an element and when the level is sufficient in the soil no further additions of fertiliser are made. They argued that the maintenance method could justify applying the amount of fertiliser that was removed by the crop, even at soil levels beyond the sufficiency level approach. The Irish system outlined in this paper is a combination of the sufficiency method and the maintenance method. The Irish advice is that no fertiliser at all is recommended for grassland beyond 10 mg/l (Morgan's extract). Below this the maintenance methods is used between 6.0 and 10 mg/l. Research is ongoing on the soil Index System, and there is some preliminary evidence that further modifications to the Index system may be possible in the future.

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RECOMENDACIONES DE ABONADO FOSFÓRICO PARA PRADERAS UTILIZADAS EN PASTOREO

RESUMEN

El fósforo es un elemento esencial para el crecimiento de plantas y animales. Mientras que la agricultura no es posible en suelos con muy bajo contenido en fósforo, existe una creciente evidencia de que un alto contenido en fósforo en los suelos puede llevar a una transferencia del fósforo desde los sistemas agrícolas al agua. Estas recomendaciones tienen como objetivo asegurar producciones óptimas con consumos mínimos de P. La estrategia de fertilización se basa en tres principios. El primero es conseguir un nivel de P en el suelo, de modo que se garantice una producción óptima. Para una agricultura intensiva el nivel de P necesario está entre 6,1 y 10,0 mg P/l (extracción en la solución de Morgan). En sistemas más extensivos es suficiente con que el contenido en P esté entre 3,1 y 6,0 mg P/l. Una vez conseguido este nivel, el segundo principio es que el abonado con P es para reemplazar al P retirado del suelo por el sistema de producción. Con cargas ganaderas de 2,0-2,5 unidades de ganado mayor por hectárea, las necesidades de mantenimiento son de 9 y 5 kg/ha de P para vacuno de leche y carne, respectivamente. El tercer principio es que el suelo debe analizarse cada cuatro años para conocer su contenido en P, con objeto de comprobar que la estrategia de fertilización es correcta.

Palabras clave: Vacuno de leche, vacuno de carne