THE INFLUENCE OF SULPHUR ON THE YIELD OF A GRASS-CLOVER PASTURE FERTILIZED WITH DIFFERENT SOURCES OF PHOSPHORUS

(Met opsomming in Afrikaans)

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Abstract

Soil and plant samples were obtained from an experiment comparing single superphosphate and Langebaan rock-phosphate as sources of P for a grass-legume pasture. P and S analyses demonstrated that the marked yield increases from plots receiving annual top-dressings of superphosphate were, in fact, due to S and not P. The S requirements of a grass-clover pasture appeared to be in excess of 30 kg/ha/annum. The suggestion is made, that with increased use of high-analysis fertilizers, dependence on extraneous sources of S will have to be replaced by a planned programme for S fertilization.

Introduction

Sulphur has been recognised as an essential plant nutrient for over 150 years, yet has received only sporadic study by agronomists. This neglect is undoubtedly due largely to the fact that incidental additions of sulphur in other fertilizer materials have generally ensured an adequate supply for crop requirements. The current trend towards the use of high-analysis fertilizers, which contain insignificant quantities of sulphur, however, has contributed, and will continue to contribute to the development and discovery of new areas of sulphur deficiency. In this country there has also been a tendency to over-emphasise the importance of atmospheric sulphur are negligible (Rossiter, 1952; Jordan, in rainfall is often sufficient for crop needs in highly industrialised areas (Alway, Marsh & Methley. 1937; Bertramson, Fried & Tisdale, 1950). In rural areas, however, except those in close proximity to the sea, accessions of atmospheric sulphur are neglible (Rossiter, 1952; Jordan, Bardsley, Engsminger & Leitz, 1959; Freney, Barrow & Spencer, 1962; Whitehead, 1964). Only a small percentage of the arable land in this country is likely to benefit materially from atmospheric sulphur.

Croft (1969) established in a series of pot trials that many Natal soils are inherently deficient in sulphur. Deficiencies of sulphur have also been positively diagnosed in high-producing irrigated Natal pastures. In recent years several dryland pasture experiments in East Griqualand and the Natal Midlands have developed deficiency symptoms very similar to those associated with sulphur shortages.

This paper presents some preliminary results relating to the sulphur requirements of a grass-clover pasture near Kokstad, East Griqualand.

Materials and methods

The data discussed in this paper were obtained from an experiment designed to test the effects of various types and levels of lime and phosphate on the yield of a grass (*Paspalum dilatatum*)-clover (*Trifolium repens* cv Ladino white) pasture.

The experiment was established in the spring of 1967 on a virgin Killarney clay. Selected physical and chemical properties of the topsoil are presented in Table 1.

TABLE 1 Selected physical and chemical characteristics of a Killarney clay (0-15 cm)

Particle size distribution (hydrometer)	
Sand (%)	25,8
Silt (%)	23,4
Clay (%)	50,8
ph (Soil:Solution ratio 1:2)	
H_2O	6,59
N KCl	5,73
Organic carbon (%)	3,17
Nitrogen (%)	0,27
Carbon:nitrogen ratio	12:1
0,05 N H_2SO_4 Extractable phosphorus (ppm)	35
Extractable cations (N NH_4OAC pH7)	
Calcium (me%)	17,06
Magnesium (me%)	7,86
Potassium (me%)	0,51
Sodium (me%)	1,20
Sum of metal cations (me%)	26,63
Cation exchange capacity (me%)	32,99
Percentage base saturation	80,7

Fertilizer treatments were applied to 0,0038-hectare plots in a two replicated 2^5 factorial arrangement. Two levels of 2 per cent citric acid-soluble P (45,0 and 135,0 kg P/ha) were applied as Langebaan rockphosphate (1 450 and 4 350 kg/ha) and single superphosphate (530 and 1 590 kg/ha). Single superphosphate contains 8,3 per cent water-soluble P and 10-12 per cent S, while Langebaan rock-phosphate is water insoluble and does not contain S.

The P was applied either as a basal-dressing or as an annual top-dressing, 1/5 of the total amount being applied at planting and at the start of each season. For reasons which are not clear, considering the already high base saturation (Table 1), two levels of agricultural lime and dolomitic lime (265 and 2 120 kg/ha) were applied six months prior to establishment. Uniform applications of 105 kg/ha potassium chloride and 50 kg/ha urea were disced into the soil just prior to planting. Thereafter, two top-dressings of potassium chloride each of 130 kg/ha, and four top-dressings of urea, each of 200 kg/ha, were applied annually.

No trace elements were applied. Moreover, no attempt was made to compensate for the very different quantities of sulphur contained in the two P carriers.

For the purposes of this study, topsoil samples (0-15 cm) were taken from each plot immediately after the fourth cut during the 1969/70 season, air dried and ground to <1 mm. A grab sample (± 500 g) was obtained from the herbage yield of each plot after the fifth cut, oven dried at 90°C and milled.

An index of soil P availability was obtained by the phosphomolybdovanadate method after a five minute extration of 10 g of soil with 100 ml of 0,05 N H_2SO_4. Sulphate S in the soil was determined using the method of Bardsley & Lancaster (1960).

Plant P was determined by the phosphomolybdovanadate method in filtered extracts obtained after ashing 2 g samples at 450°C and dissolution in 1+4 HCl. Total plant S was determined using the method of Blanchar, Rehm & Caldwell (1965).

Results

The effects of level of P, form of P and method of P application on the yield of the fifth cut during the 1969/70 season are shown in Table 2.

Top-dressings of superphosphate at both the low and high rates resulted in yields significantly higher than those obtained with rockphosphate. Yield increases from plots receiving the high superphosphate top-dressing were particularly marked. Analysis of soil and plant samples suggested that these growth differences were due largely to some factor other than P. Both soil and plant P were poorly related to yield (Tables 3 and 4).

*TABLE 2 Effects of P level, form of P and method of P application on the yield of a grass-clover pasture**

P carrier	Yield of fifth cut (kg/ha)			
	Annual top-dressing (kg P/ha)		Basal application (kg P/ha)	
	45,0	135,0	9,0	27,0
Langebaan rockphosphate	855,5	796,1	805,5	814,2
Single superphosphate	927,9	817,3	1 076,4	2 258,1

*Level of P expressed on a 2% citric acid soluble basis
SE Body of table = 82,87
LSD's Body of table = 241,5 (5%) 326,6 (1%)

TABLE 3 Effects of P level, form of P and method of P application on the content of a Killarney clay

P carrier	Content of soil after fourth cut (ppm)			
	Basal application (kg P/ha)		Annual top-dressing (kg P/ha)	
	45,0	235,0	9,0	27,0
Langebaan rockphosphate	87,2	106,9	46,8	59,4
Single superphosphate	56,8	85,1	51,0	53,0

SE Body of table = 4,58
LSD's Body of table = 13,3 (5%) 18,1 (1%)

TABLE 4 Effects of P level, form of P and method of P application on the P content of a grass-clover pasture

	P content of forage (ppm)			
	Basal application (kg P/ha)		Annual top-dressing (kg P/ha)	
	45,0	135,0	9,0	27,0
Langebaan rockphosphate	1 660	2 120	2 010	3 040
Single superphosphate	1 990	2 180	1 540	1 860

SE Body of table = 83,1
LSD's' Body of table = 2 420 (5%) 3 270 (1%)

TABLE 5 Effects of P level, form of P and method of P application on the sulphate S content of a Killarney clay

P carrier	Sulphate S content of soil after fourth cut (ppm)			
	Basal application (kg P/ha)		Annual top-dressing (kg P/ha)	
	45,0	136,0	9,0	27,0
Langebaan rockphosphate	3,6	3,6	1,7	2,4
Single superphosphate	2,4	3,3	4,9	18,7

SE Body of table = 1,28
LSD's Body of table = 3,7 ((5%) 50 1%)

TABLE 6 Effects of P level, form of P and method of P application on the S content of a grass-clover pasture

P carrier	S content of forage (ppm)			
	Basal application (kg P/ha)		Annual top-dressing (kg P/ha)	
	45,0	135,0	9,0	27,0
Langebaan rockphosphate	1 009	889	919	859
Single superphosphate	899	987	1 061	2 601

SE Body of table = 75,6
LSD's Body of table = 220 (5%) 298 (1%)

Soil and plant S, on the other hand, were closely related to yield (Tables 5 & 6). Growth differences appeared to have been largely due to the beneficial effects of S contained in the superphosphate.

Discussion

The data presented here strongly suggest that S rather than P was responsible for the marked yield differences obtained.* Insufficient S levels (superphosphate top-dressings) make it difficult to determine whether or not the response was maximised. It is feasible that higher S applications might have resulted in further yield increases and/or a pasture of superior quality. Grasses in a mixture compete so vigorously for S supplies that legumes often make little growth under conditions of low S supply (Walker & Adams, 1958; Jones, 1964). No assessment was made of the ratio of grass to clover which existed under the various fertilizer regimes. However, the S content of plant material from plots receiving the highest level of top-dressed superphosphate, equivalent to 32 kg S/ha/annum, was very similar to threshold values which have been proposed by other workers for grass-clover mixtures (McNaught & Chrisstoffels, 1961; Martin & Walker, 1966). Further work, initiated recently, has been designed specifically to establish the quantity of S required annually to optimise both yield and quality of a *Paspalum-clover* pasture.

Notwithstanding the rather exploratory nature of the work discussed in this paper, its practical significance, with regard to current pasture fertilization trends in Natal, is inescapable. Upgraded P fertilizers and Langebaan rockphosphate which contain insignificant quantities of S, are used extensively in pasture production. Furthermore, many of the modern fertilizer mixtures contain very little S, since the P is derived basically from upgraded sources. High-analysis fertilizers are attractive to industry and to the farming community because of savings in the cost of production, transportation, handling and application. Similarly, Langebaan rockphosphate presently enjoys a widespread popularity based largely on economic considerations. Clearly, however, failure to give due consideration to S in the fertilization programme will nullify any economic benefits which might accrue from use of these materials. It is important that a planned programme for S fertilization should replace dependence on extraneous sources unless these are known to be adequate.

S-containing compounds such as gypsum, ammonium sulphate, potassium sulphate, and potash magnesia can be used to satisfy plant requirements for S. Alternatively, greater use can be made of single superphosphate. Although use of single supers eliminates the possible savings which make high-analysis fertilizers so attractive, these savings are possibly less than the increased costs incurred by use of alternative S carriers. Similarly, any decision to use rockphosphate should be made in the knowledge that supplementary S-fertilization may be required.

S-containing high-analysis fertilizers are produced commercially in the USA and a final solution to the problem probably depends on the local production, by industry, of such products.

* In subsequent work, plots have been split and S applied in the form of gypsum (200 kg/ha) to half of each plot. Yield increases in the plots not receiving high top-dressings of single superphosphate are, in many instances, in excess of 1 000 per cent.

Opsomming

DIE INVLOED VAN SWAEL OP DIE OPBRENGS VAN 'n GRAS-KLAWERWEIDING WAT MET VERSKILLENDE BRONNE VAN FOSFOR BEMES IS

Grond- en plantmonsters was verkry uit 'n proef waarin enkelsuperfosfaat en Langebaan-rotsfosfaat as bronne van P vergelyk was op 'n gras-klawerweiding.

P- en S-ontledings het getoon dat die merkbare toename in opbrengs op die persele wat 'n jaarlikse toediening van superfosfaat as bobemesting ontvang het, nie aan P toegeskryf kan word nie, maar wel aan S. Dit wil voorkom asof die S-benodigdhede van 'n gras-klawerweiding meer as 30 kg/ha/jaar is.

Die voorstel word gemaak dat met die toenemende gebruik van hoëgraadse kunsmisstowwe die afhanklikheid van toevallige bronne van S vervang sal moet word met 'n beplande program vir S-bemesting.

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