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The Utilization of the Protein of Somerset Beans by Rats and Sheep.

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EXPERIENCE and practical results have demonstrated beyond doubt that the future of Animal Production in South Africa is largely predetermined by the amount and type of available nutritious feeds during those seasons of the year, when the natural flora has deteriorated to such an extent that it becomes nutritionally inadequate to maintain animals subsisting solely on it. The problem of national importance arising from this complex situation, resolves itself, therefore, primarily into devising means and ways by which adequate amounts of feed can be ensured during those periods when supplementary feeding becomes absolutely essential. Unfortunately climatic conditions prevailing in the larger portions of the animal production areas do not favour extensive production of home-grown fodder during winter. Except in rare and fortunate cases where irrigation may be executed farmers have to rely almost exclusively for winter feeding on such amounts of feed which could be conserved during, and carried over from the preceding summer. This highly essential practice of food conservation is, however, not yet fully appreciated in practice, so that in many instances either no effort is made to conserve feed or inadequate amounts are conserved which becomes exhausted early in winter. This precarious position coupled with unreliable summer rainfall conditions, as well as the great bulk of plant material required to ensure adequate reservation of feed during winter make it highly debatable whether it would not be far more practical and economical to adopt the principle of concentrate supplementation. In fact, it has been shown in a previous publication that our national feed namely, maize, is particularly suitable for such a purpose and when the condition arises it may be scientifically supplemented with other available protein feeds to make a complete balanced ration for any specific animal function. However, at present every progressive farmer is endeavouring in his own way to combat this evil of winter feeding, and a variety of individual methods are in existence.

During the summer months of 1938 one of the authors (J.C.B.) visited several cattle ranches in the Northern Transvaal. On one of these ranches at Bandolierskop, he was struck by the abundant vegetative growth of a type of velvet bean.

He was informed that these beans came from Southern Rhodesia and that the seed was mixed with sunflower seed; the result was that the vines which often attain a length of 20 yards or more grew over the sunflower stems. (Figure 1.)

These beans were later identified as a velvet bean (Stizolobeum) called Somerset beans.

According to information obtained from Mr. D. E. McLoughlin, Agriculturist, Southern Rhodesia, this variety of velvet bean was introduced from India in 1926, and it soon proved to be superior to any which had previously been grown in the Colony.

In trials at the Salisbury Agricultural Experiment Station during 1927-1929 the following yields were obtained per acre, viz., green fodder 25,497 lb., hay 4,793 lb., seed 2,690 lb. The Experiment Farm, University of Pretoria, obtained a yield of 4,301·8 lb. of hay per acre in the first trial in 1939. A farmer in Northern Transvaal reported a yield of over 4,000 lb. of seed per acre.

It appears that in Southern Rhodesia the Somerset variety is practically the only variety of velvet bean grown in the colony, where it is used chiefly as a hay or silage crop.

In the Northern Transvaal, farmers allow the crop to mature. The whole plant is then ground, in a hammermill and molasses added. This feed is well liked by cattle and very good results have been observed when the hammermilled Somerset beans sprayed with molasses have been fed to cattle.

Because of this apparent nutritive value and the high yields of hay and beans, it was decided to undertake certain protein studies on these beans.

Description.

It would be of interest to describe the Somerset bean briefly and to mention important facts of practical interest to the grower or farmer.

The Somerset bean is a vigorously growing annual, which requires a long growing season.

Under favourable conditions the vines may attain a length of 20 yards or more.

The leaves are trifoliate, the leaflets are entirely ovate, with laterals oblique, acuminate and pubescent on the lower side. (Figure 2.)

The flowers, which are papilionaceous, are dark purple, 15 to 30 being produced on a long pendent branched raceme in groups of 3-5 on short lateral branchlets. (Figure 3.)

There are from 10 to 30 pods on a lateral branch; the former are pubescent when immature. (Figure 4.)

The mature pods are smooth, 5½ inches long, with one twist; they are longitudinally ridged. There are usually from 5 to 8 oval, smooth, black marbled seeds in each pod. (Figure 5.)

PLANTING.

As the Somerset bean requires a long growing season, planting should take place early in the spring. The mealie planter can be used but the holes in the discs should be made larger in order to enable the beans to pass through.

This crop is usually planted 3-4 inches deep in rows 36-40 inches apart with 18 inches between plants in the rows.

A supporting crop, such as sunflowers, increases the yield of seed of Somerset beans. The sunflowers should be sown in the same rows as the beans and about 3-4 feet apart.

HARVESTING.

If the crop is harvested with the object of grinding the whole plant in a hammermill, it should be allowed to mature. Harvesting is carried out by chopping off the plants with a native hoe.

When required for silage, planting should take place later, and the crop should be cut when the pods are 1 to 1½ inches long.

A mixture of 2 parts of maize or wintersome to one of velvet beans makes excellent silage.

Fig. 1.

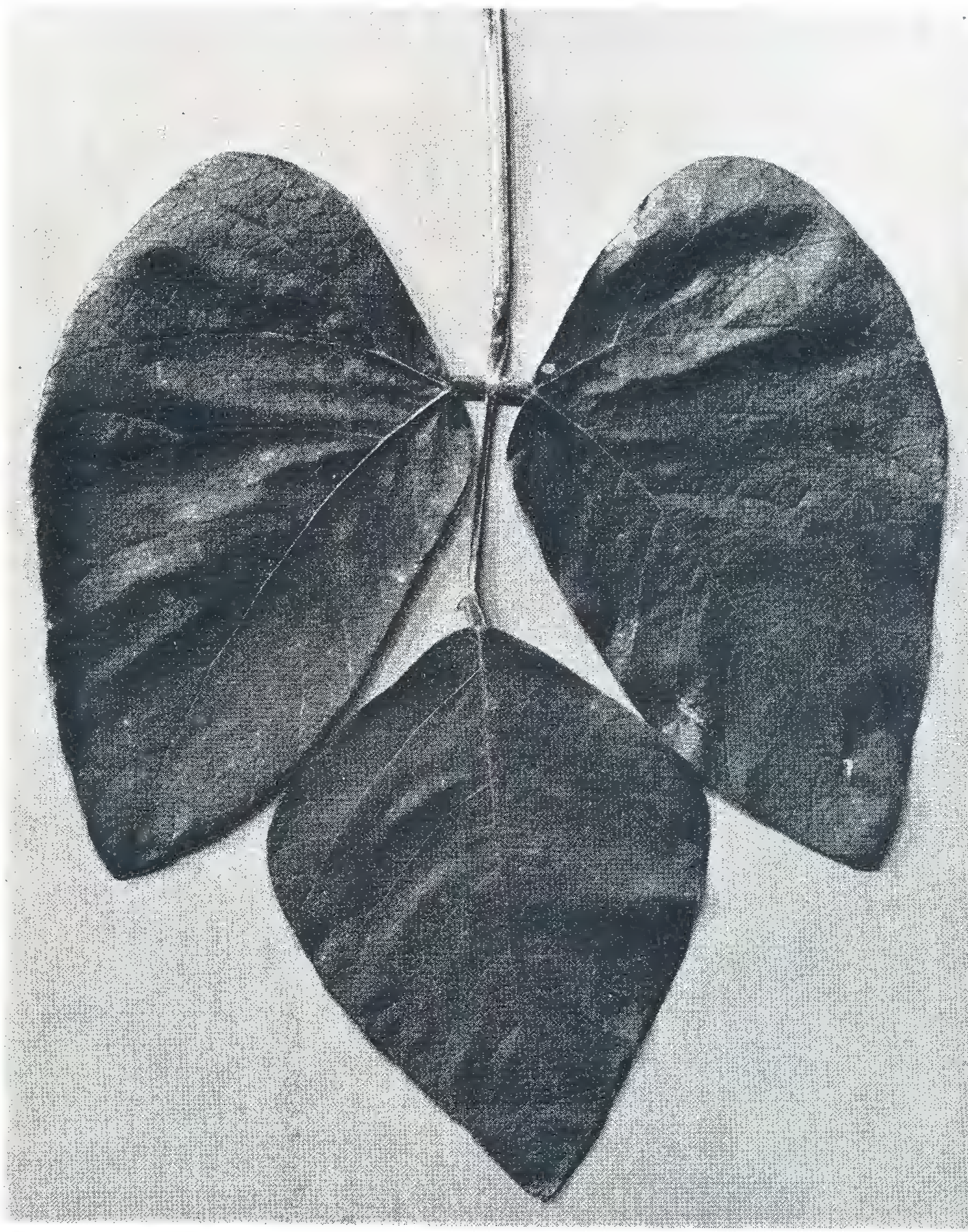

Fig. 2.

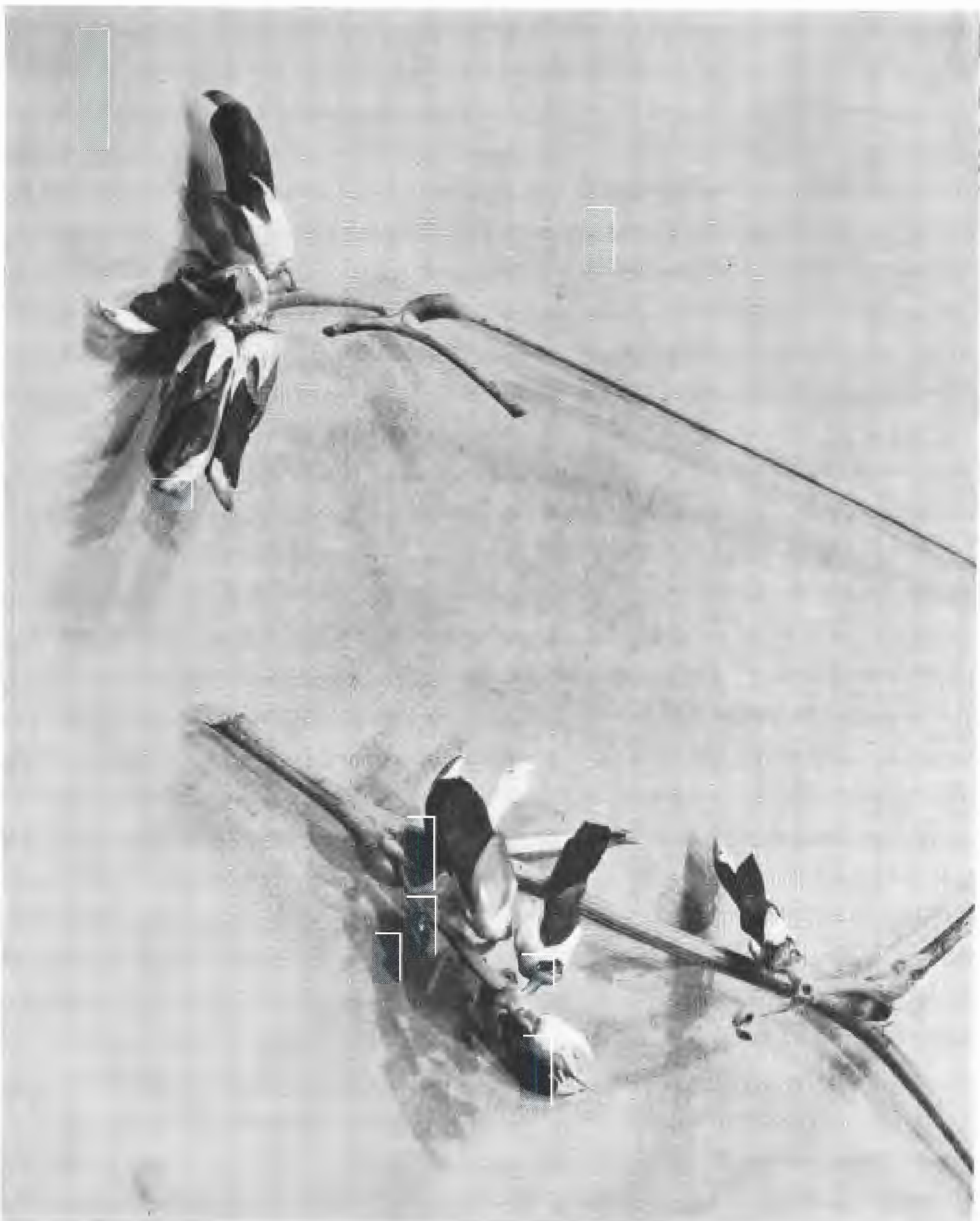

Fig. 3.

Fig. 4.

Fig 5.

The popularity of this crop in Southern Rhodesia and in the Northern Transvaal is due mainly to its ability to thrive under great variation in climatic conditions, also the crop does well on comparatively poor soils. However adverse the climatic conditions may be it seldom fails to yield a crop.

This crop is relatively immune to fungoid disease, is attacked by few insects and is nematode resistant.

Experimental.

The biological value of Somerset bean proteins was determined alone and supplemented by cystine at an 8 per cent. level on rats. These rats were selected according to the usual procedure for the determination of the biological values. They were subjected to a nitrogen free period for the estimation of the body's contribution of nitrogen in the faeces and urine and thereafter put on the protein rations for a preliminary period followed by the usual collection period of 8 days. The composition of the rations is given in Table 1.

Young Merino wethers accustomed to the metabolism crates were utilized to determine the biological value of the Somerset beans. Two periods, one in which Somerset beans alone were fed and the other in which it was supplemented by maize at the same level of nitrogen intake, were run on these immature sheep. A third period in which grazing cut at Ermelo during April was supplemented by Somerset beans, was conducted on mature sheep.

Experimental Results.

In Table 2 are given the detailed results relevant to the calculation of the biological value of Somerset beans on rats. It is at once evident from this table that a large proportion of the nitrogen contained in the above bean is excreted as undigested waste in the faeces. However, the average apparent digestibility of 57 is not a true index of the digestibility of Somerset bean nitrogen since the nitrogen derived from the body and excreted in the faeces is included in the calculation. If the metabolic fecal nitrogen is deducted, then the true digestibility as shown in the table is enhanced and becomes 76. The utilization of the absorbed nitrogen as represented by an average biological value of 37 is indeed low, and indicates that the quality of the protein of this bean is exceptionally poor for maintenance and growth of rats. It is thus evident that certain of the essential amino acids are definitely missing from the amino acid complex constituting the protein molecule of this bean.

Working on this hypothesis, it was decided on the ground of our previous experience with plant proteins to supplement the protein of Somerset beans with 0·2 per cent. of cystine. The results obtained with this supplementation are reproduced in Table 3. From this data it appears as if the apparent digestibility is lowered by the inclusion of this minute amount of cystine. That such should be the case is hardly conceivable, unless the effect of the cystine ingestion is to stimulate the metabolic fecal nitrogen enhancing the total fecal nitrogen excretion. However, of more importance is the fact that the inclusion of cystine makes the absorbed nitrogen better utilizable by 17 per cent. Somerset beans alone as shown in Table 2 gives a biological value of 37 whereas after supplementation with cystine the biological value is increased to 54. This data definitely confirms an existing deficiency of the indispensable amino acid cystine in the protein of this bean.

In Table 4 are reproduced in tabular form the results in connection with the sheep metabolism experiments. In the first series the biological value of Somerset beans was determined at an approximate level of 7 per cent. protein. The apparent digestibility of 48 as obtained per sheep agrees fairly well with that obtained for rats when cystine supplementation was executed. The true digestibility of 87 is, however, slightly better than 73 obtained for rats. Without cystine supplementation the apparent digestibility with rats is approximately 10 per cent. higher, while the difference in true digestibility remains more or less of the same magnitude. The average biological value obtained under these conditions is 52. This value is decidedly very low for growing sheep at this level of protein feeding. Judging from this result it would appear as if this particular protein is also deficient in some or other indispensable amino acid for the growth requirements of sheep. Thus far it has been assumed on purely theoretical grounds (Rimington and Bekker) that cystine can be synthesized by sheep. This assumption has no experimental basis and is chiefly based on cystine content of wool in comparison with that of grazing. Smuts and Marais have definitely shown that the biological value of lucerne supplemented by cystine is not enhanced above that of lucerne. However, the condition may be quite different in respect to the growing sheep, which may, like rats, require additional cystine above that supplied by lucerne for tissue synthesis.

From the second series of metabolism tests in which half of the Somerset bean protein was displaced by that of maize protein, it would appear as if supplementation has actually taken place. If, however, the biological value of maize at this level of intake is the same as that for rats, namely 67, then one would expect a biological value for the mixed proteins of 60. This value is only 2 per cent. lower than the determined value of 62, and cannot therefore be considered statistically significant. Superficially it would appear as if maize which is known to supplement cystine deficient protein (Smuts and Marais) does not exert this effect with Somerset beans, which may lead one to suspect that either the cystine requirements of sheep are very low and that it is not the limiting amino acid for sheep in Somerset beans, or that sheep can actually synthesize this amino acid. However, it is hoped these points will be settled in the following publication.

In the last series of results, 320 grams of April grazing was supplemented by 100 grams of Somerset beans. Both the apparent digestibility and true digestibility are increased under these conditions. The biological value of 59 is fairly good at this level of protein intake for growing sheep.

If the Smuts and Marais formula for the estimation of the protein requirements of sheep, namely $P = \cdot 74\ W^{\cdot 734}$ is utilized, it is found that a 100 lb. sheep requires 13·0 grams utilizable protein for maintenance. To satisfy this need by the feeding of Somerset beans it would require 194 grams or 7 oz. of the latter beans. On the other hand, if the general formula of Smuts, namely $P = \cdot 88\ W^{\cdot 734}$ applicable to all species be applied to determine the maintenance requirement of steers, it is found that a 1,000 lb. steer would require 82 grams utilizable protein. In order to satisfy this need through the feeding of Somerset beans, 1,254 grams or approximately 2·7 lb. are to be fed. From the data on the grazing supplemented by Somerset beans it is evident that considerably less is necessary to satisfy the maintenance protein needs of both sheep and cattle.

It must be understood that the requirements as calculated above is only in respect to the protein requirements of the respective species. There is little doubt that the energy contained in the above quantities will considerably augment the depleted energy in the grazing and may even help to satisfy the needs of this element in a substantial way, and may, together with the prctein, be the cause of the excellent practical results obtained on it.

Conclusion.

By means of carefully controlled metabolism experiments it was shown that the biological value for Somerset beans with rats is 37, and that this value is significantly enhanced by the inclusion of 0·2 per cent. cystine.

The same product when tested out with sheep gave a biological value of 52, and when supplemented in equal proportions, with maize, a value of 62. When April grazing is supplemented by Somerset beans the average biological value obtained is 59.

TABLE 1.

Composition of Rations.

	A.	B.	C.?
Somerset beans	30·1	—	30·1
Butterfat	8·0	8·0	8·0
Cystine	—	—	0·2
Codliver oil	2·0	2·0	2·0
Harris yeast	2·0	2·0	2·0
Sucrose	10·0	10·0	10·0
Salt mixture (Hubbel)	2·0	2·0	2·0
NaCl	1·0	1·0	1·0
Starch dextrinized	44·9	69·2	69·2
Whole egg (ether extracted)	—	3·8	—
Agar	—	2·0	—
	100·0	100·0	—
Percentage N	1·56	0·64	1·50

TABLE 2.

Biological Value of Somerset Bean Ration.

Nitrogen Metabolism Data and the Calculation of the Biological Value.

N-low Period.

Rat No.	Sex.	Initial Wgt.	Final Wgt.	Average Wgt.	Daily Food Intake.	Daily N Intake.	Daily Faecal N.	Metabolic N.		Food N in Faeces	Absorbent Nitrogen.	Daily Urinary N.	Endogenous N.		Food N in Urine.	Retained Nitrogen.	Biological Value.	True Digestibility.	Apparent Digestibility.
								Per Gram Food.	Per Day.				Per 100 Gram Wgts.	Per Day.					
		Gm.	Gm.	Gm.	Gm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.			
1	—	96	97	97	5·0	—	14·6	2·92	—	—	—	11·2	11·5	—	—	—	—	—	—
	—	98	100	99	6·8	—	22·0	3·24	—	—	—	17·2	17·4	—	—	—	—	—	—
	—	95	97	96	8·0	—	19·6	2·45	—	—	—	23·2	24·2	—	—	—	—	—	—
4	—	90	87	89	4·7	—	16·4	3·49	—	—	—	17·2	19·3	—	—	—	—	—	—
5	—	97	97	97	5·0	—	16·0	3·20	—	—	—	13·2	13·6	—	—	—	—	—	—
6	—	109	110	110	8·5	—	20·4	2·40	—	—	—	21·2	19·3	—	—	—	—	—	—
Somerset Bean Ration 1.·56 per cent. N.																			
1	—	100	90	95	8·0	124·8	53·6	2·92	23·4	30·2	94·6	69·6	11·5	10·9	58·7	35·9	38	76	57
2	—	101	91	96	7·4	115·4	52·0	3·24	24·0	28·0	87·4	73·6	17·4	16·7	56·9	30·5	35	76	55
3	—	104	92	98	8·1	126·4	45·6	2·45	19·8	25·8	100·6	91·2	24·2	23·7	67·5	33·1	33	80	64
4	—	95	89	92	8·1	126·4	60·0	3·49	28·3	31·7	94·7	74·4	19·3	17·8	56·6	38·1	40	75	53
5	—	102	90	96	8·7	135·7	64·0	3·20	27·8	36·2	99·5	76·8	13·6	13·1	63·7	35·8	36	73	53
6	—	107	101	104	8·4	131·0	50·4	2·40	20·2	30·2	100·8	81·6	19·3	20·1	61·5	39·3	39	77	62
																	37	76	57

TABLE 3.

Biological Value of Somerset Bean + 0·2 per cent. Cystine.

Nitrogen Metabolism Data and the Calculation of the Biological Value.

N-low Period.

Rat No.	Sex.	Initial Wgt.	Final Wgt.	Average Wgt.	Daily Food Intake.	Daily N Intake.	Daily Faecal Intake.	Metabolic N.		Food N in Faeces	Absorbent Nitrogen.	Daily Urinary N.	Endogenous N.		Food N in Urine.	Retained Nitrogen.	Biological Value.	True Digestibility.	Apparent Digestibility.
								Per Gram Food.	Per Day.				Per 100 Gram Wgts.	Per Day.					
		Gm.	Gm.	Gm.	Gm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.			
1	—	121	117	119	8·1	—	32·0	3·95	—	—	—	19·7	16·6	—	—	—	—	—	—
2	—	125	125	125	9·8	—	38·4	3·92	—	—	—	24·6	19·7	—	—	—	—	—	—
3	—	131	127	129	7·9	—	34·0	4·30	—	—	—	27·9	21·6	—	—	—	—	—	—
4	—	124	120	122	7·6	—	29·6	3·89	—	—	—	23·6	19·3	—	—	—	—	—	—
5	—	124	126	125	11·8	—	45·6	3·86	—	—	—	26·8	21·4	—	—	—	—	—	—
6	—	130	126	128	10·3	—	42·0	4·08	—	—	—	26·0	20·3	—	—	—	—	—	—
Somerset Beans + 0·2 per cent. Cystine per cent N 1·53.																			
1	—	110	102	106	8·8	134·6	64·4	39·5	34·8	29·6	105·0	63·4	16·6	17·6	45·8	59·2	56	78	52
2	—	112	105	109	9·4	143·8	75·2	3·92	36·8	38·4	105·4	72·4	19·7	21·5	50·9	54·5	52	73	48
4	—	108	98	103	7·1	108·6	59·2	3·89	27·6	31·6	77·0	64·2	19·3	19·9	44·3	32·7	42	71	45
4	—	108	98	103	7·1	108·6	59·2	3·89	27·6	31·6	77·0	64·2	19·3	19·9	44·3	32·7	42	71	45
5	—	110	104	107	8·9	136·2	66·4	3·86	34·4	32·0	104·2	61·5	21·4	22·9	38·6	65·6	63	77	51
6	—	111	102	107	9 7	148·4	95·6	4·08	39·6	56·0	92·4	61·3	20·3	21·7	39·6	52·8	57	62	36
																	54	73	47

TABLE 4.

Data on the Nitrogen Utilization of Somerset Beans with Sheep.

Animal No.	Average Lot.	Food Consumption.			Dry. Matter Intake.	Nitrogen Intake.	N in Faeces.	Metabolic Faecal N.‡	Absorbed N.	N in Urine.	Endogenous N.*	Food N Retained.	Biological Value.	N Balance.	Apparent Digestibility.	True Digestibility
		Wheat Straw.	Somerset Beans.	Starch.												
	Kgm.	Gm.	Gm.	Gm.	Gram.	Gram.	Gram.	Gram.	Gram.	Gram.	Gram.	Gram.		Gram.	Per cent.	Per cent.
1	27	300	100	100	460	5·73	2·80	2·30	5·23	3·31	0·83	2·75	53	−0·39	52	91
2	27	300	100	100	460	5·73	3·12	2·30	4·91	3·24	0·83	2·50	51	−0·63	46	86
3	26	300	100	100	460	5·73	3·21	2·30	4·62	3·08	0·81	2·35	51	−0·56	44	81
4	26	300	63	13	346	4·15	2·14	1·73	3·74	2·66	0·81	1·99	53	−0·65	48	90
5	26	300	100	63	418	5·73	2·95	2·09	4·87	3·25	0·81	2·43	50	−0·47	49	85
												Average	52	—	48	87
Maize.																
1	27	300	50	125	437	5·65	2·51	2·19	5·33	3·08	0·83	3·08	59	+0·06	56	94
2	27	300	50	125	437	5·65	2·63	2·19	5·21	2·74	0·83	3·30	63	+0·28	53	92
3	26	300	50	125	437	5·65	2·62	2·19	5·22	2·74	0·81	3·29	63	+0·29	53	92
4	26	300	50	125	437	5·65	2·48	2·19	5·36	2·77	0·81	3·40	63	+0·40	56	95
5	26	300	50	125	437	5·65	3·17	2·19	4·67	2·66	0·81	2·82	60	−0·18	44	83
												Average	62	—	52	91
Mature sheep April grazing + Sussex Beans.																
7	43	320	—	100	387	7·36	2·52	1·94	6·78	4·16	1·17	3·79	56	+0·68	66	92
8	40	320	—	100	387	7·36	2·81	1·94	6·49	3·75	1·10	3·84	59	+0·80	62	88
9	40	320	—	100	387	7·36	3·09	1·94	6·21	3·75	1·10	3·56	57	+0·52	58	84
10	40	320	—	100	387	7·36	2·45	1·94	6·85	3·46	1·10	4·49	65	+1·45	67	93
												Average	59	—	63	89

* The endogenous N was calculated from $P. = \cdot 74\ W^{\cdot 734}$

‡ The metabolic fecal N was calculated from the average figure of ·005 grams N per gram dry matter consumed.