Feeding potential of summer grain crop residues for woolled sheep in the south-eastern Transvaal Highveld. I. Availability of crop residues and sheep mass changes

Christina D. Esterhuyse* and S.D. Niemand
Nooitgedacht Research Station, P.O. Box 3, Ermelo 2350, Republic of South Africa
H.H. Meissner
Department of Livestock Science, University of Pretoria, Pretoria 0002, Republic of South Africa

Received 7 June 1990; revised 28 September 1990; accepted 15 March 1991

In a two-year study, the value of crop residues of lupins, dry beans, soybeans, sunflower, sorghum and maize for wintering sheep was evaluated. The amounts of residues and weeds present at the start and end of grazing were estimated by means of quadrat samples. Maize cobs were picked up. Amount of residues and the ratio of grain to straw at the start of grazing differed in the two seasons and differences occurred between crops. Weeds were an important source of feed. The extent of utilization of total dry matter and individual components varied between crops and components. The crop residues were each grazed by 10 mature Döhne Merino wethers/ha. Midrib wool samples were collected in the second season. The sheep initially gained and then lost mass. They were removed from the trial when they had reached the starting mass. Sheep on dry, bean residues gained least during both seasons. Sheep on sorghum residues had the highest average ADG of 98 g over the two seasons, while sheep on soybean residues gained disappointingly with an ADG of only 47 g. Grazing periods differed between seasons. The total length of the grazing period was much the same between crops, except for dry beans where it was markedly shorter. Clean yield percentage was about 61% and did not differ between residues. The wool growth rate of sheep on all crops except on lupins was similar and varied from 0,24 to 0,28 g/d/100 cm^2. Sheep on lupins had a wool growth rate of 0,53 g/d/100 cm^2.

In 'n studie oor twee jaar is die waarde van oesreste van lupiene, droëbone, sojabone, sonneblom, sorghum en mielies geëvalueer. Die hoeveelheid reste asook onkruid is met aanvang en beëindiging van beweiding bereken volgens kwadraatmonsters. Mieliekoppe is opgetel. Die hoeveelheid reste en die verhouding van graan tot strooi aan die begin van beweiding het in die twee seisoene verskil en verskille het ook tussen gewasse voorgekom. Onkruid was 'n belangrike bron van voer. Die mate van benutting van die totale droë materiaal en die onderskeie komponente het tussen gewasse en komponente verskil. Die oesreste is deur tien volwasse Döhnemerinohamels/ha bewei. Midribwolmonsters is in die tweede winter geneem. Beweiding is gestaak nadat die skape na piekmassa, weer dieselfde massa as hul aanvangsmassa bereik het. Skape op droëboonreste het gedurende beide seisoene die minste in massa toegeneem. Skape op die sorghumreste het die hoogste gemiddelde GDT van 98 g oor die twee seisoene getoon, terwyl skape op die sojaboonreste telleurstellend gevaar het met 'n GDT van slegs 47 g. Weiperiode het tussen die twee seisoene verskil. Totale lengte van weiperiode was ongeveer dieselfde tussen gewasse, behalwe vir droëbone waar dit heelwat korter was. Persentasie skoonwol was ongeveer 61% en het nie tussen gewasse verskil nie. Die wolgroeitempo van die skape op al die gewasse, behalwe op lupiene, het gewissel vanaf 0,24 tot 0,28 g/d/100 cm^2. Skape op lupiene het 'n wolgroeitempo van 0,53 g/d/100 cm^2 getoon.

Keywords: Crop residues, utilization, sheep mass changes, wool production.

* To whom correspondence should be addressed.

Introduction

Residues of grain crops are an important source of feed for wintering livestock in the south-eastern Transvaal Highveld. Current estimates for this region put the area planted at 740 000 ha maize, 117 000 ha sorghum, 77 000 ha sunflower, 14 000 ha soybeans, 41 000 ha dry beans and approximately 1 500 ha lupins (J.G. Wilson, 1988. Personal communication, OTK, Bethal).

Crop residues are a by-product of grain farming and can not be marketed. The parts that are utilized by sheep, namely the grain and finer material, cannot be recovered by mechanical means. Consequently, if crop residues were to be grazed, this would potentially be the cheapest means available to the farmer to keep livestock through the winter.

Available results on the grazing value of crop residues suggest that it is a feed source that cannot be ignored in the winter feed flow programme of the south-eastern Transvaal.

Schoonraad (1985) and Van Pletzen (1981) assessed the value of maize residues as a feed for sheep in the south-eastern Transvaal, but little information is available on the value of the crop residues of other summer grain crops commonly found in the area. In the present study, the value and utilization of residues of lupins (white), dry beans, soybeans, sunflower, sorghum (sweet) and maize were evaluated by grazing sheep. In this paper, results on the availability and utilization of residues of the above-mentioned grain crops as well as patterns of utilization by sheep are presented.

Procedure

One hectare of each of lupins, dry beans, soybeans, sunflower, sorghum and maize was planted in the spring seasons of 1985 and 1986, using standard practices. Row spacing for all crops was 0,9 m.

Weeds were controlled initially with weedicides [Eptam (EPTC), Dual (metalochlor), Treflan (trifluralin) or Basagran (bendioxide)] and later in the season by mechanical cultivation. Grain yields were determined at harvest. In

the cases of sunflower and sorghum, birds fed on the ripening grain in large numbers. Consequently, yields of grain for these crops were estimated by means of quadrats harvested when the grain started to ripen. Almost all remaining grain was utilized by the birds. Amount and composition of the crop residues present at the start and end of grazing were determined by harvesting quadrats. Ten quadrats were taken in the first season and 20 quadrats in the second season. Quadrats were 5,4 × 1 m in size for dry beans and 3,6 × 1 m for the other crops, and were placed lengthwise across the rows.

Harvested material was separated into the following components: grain, straw (leaves, stalks, cobs, ears, pods) and weeds. The components were dried and weighed.

One hectare residues of each of the six crops was grazed for two consecutive seasons using comparable groups of 10 Döhne Merino wethers/ha weighing ± 53 kg initially. An eight-day period was allowed for adaptation to grain of a specific crop by pen-feeding. In one instance, involving dry beans in Season 2, sheep were removed without gaining mass, because the grazing was depleted. In all other cases the grazing periods were terminated when average sheep mass was the same as at the beginning of the trial. Sheep were weighed weekly during the trial period. No supplements were fed and water was available *ad libitum*.

Midrib wool samples, 100 cm^2, were taken at the end of the grazing period in Season 2 only, and were analysed for clean yield and fibre diameter. At the start of grazing these surfaces were shorn clean.

Where applicable, a one-way analysis of variance was done on the data. The 95% level of probability was used.

Table 1 Grain yields of the crops (t/ha) (100% DM)

	Lupins	Beans	Soybeans	Sunflower	Sorghum	Maize
Season 1	1,8	0,8	1,3	2,4	2,0	5,6
Season 2	2,6	1,3	1,6	1,7	2,0	5,2
Average	2,2	1,1	1,5	2,1	2,0	5,4

Results and Discussion

Grain yield

Grain yields for the six crops in the 1985—86 and 1986—87 seasons (Seasons 1 and 2 respectively) are given in Table 1 on a 100% dry matter (DM) basis. These yields are considered to be normal for this region. The exceptions were soybeans and sorghum where the yields were substantially lower.

Availability of crop residues

Amount of dry material according to quadrats

The DM yields of grain, straw and weeds available at the start of grazing are shown in Table 2.

Availability of total residues and of the components grain, straw and weeds differed between seasons. The amounts available depended in part on the efficiency of combine harvesting. Much more DM was available in Season 1 than in Season 2. In both seasons, dry beans had the lowest DM yield. Comparison of grain yields in Tables 1 & 2 indicates that the percentage combine waste in the case of lupins, dry beans and maize (excluding sunflower and sorghum where bird damage was an important factor) was greater in Season 1 than in Season 2. The grain component, because of its high nutritional value, is of special importance. On the maize land about 0,02—0,46 t grain/ha was left after harvesting. Van Pletzen (1982) found 0,05—0,20 t maize grain/ha. In this study 0,21 and 0,13 t lupin grain/ha for Seasons 1 and 2 respectively, was found.

Table 2 Availability of residues before grazing (t DM/ha)

	Lupins	Beans	Soybeans	Sunflower	Sorghum	Maize	± *SE*	Differences
Grain								
Season 1	0,21	0,22	0,20	0,07	0,09	0,46	0,176	6>1,3,4,5
Season 2	0,13	0,06	0,23	0,02	0,06	0,02	0,058	1,3>2,4,5,6 3>1
Average	0,17	0,14	0,22	0,05	0,08	0,24		
Straw								
Season 1	1,82	2,09	5,17	3,42	5,00	7,24	0,953	3,4,5,6>1,2 3,5,6>4 6>3,5
Season 2	1,79	0,78	3,13	3,47	2,29	2,37	0,770	1,3,4,5,6>2 3,4>1,5,6
Average	1,81	1,44	4,15	3,45	3,65	4,81		
Weeds								
Season 1	0,76	0,42	0,10	0,22	0,15	0,25	0,437	1>3,5
Season 2	0,48	0,20	0,05	0,08	0,34	0,45	0,252	1,5,6>3,4 1,6>2
Average	0,62	0,31	0,08	0,15	0,25	0,35		
Total								
Season 1	2,79	2,74	5,47	3,71	5,23	7,95	1,008	6>3,5 3,5,6>1,2,4
Season 2	2,39	1,03	3,41	3,57	2,69	2,84	0,806	1,3,4,5,6>2 3,4>1 4>5
Average	2,59	1,89	4,44	3,64	3,96	5,40		

This is in agreement with an Australian study by Carbon *et al.* (1972), who found 0,18 t lupin grain/ha after reaping.

In the present study, 7,5 and 5,4% grain and 27,2 and 20,1% weeds were available on the lupin land in Seasons 1 and 2 respectively. According to Carbon *et al.* (1972), Arnold *et al.* (1976) and Croker *et al.* (1979), lupin residues usually consist of 1,4—6,7% grain, 15—21,6% pods, 38,5—65% stems and 8—42,6% other material (including leaves, grasses and weeds). In so far as these values are comparable, they are of the same order as those established by Carbon *et al.* (1972).

Weeds were an important source of feed and, as shown in Table 2, were well utilized. In addition, regrowth of weeds following rain in winter resulted in the availability of even greater amounts than indicated in Table 2.

Percentage utilization of residues

Using the values obtained from quadrat sampling of the residues before and after grazing, the percentage utilization of residue components could be estimated. The results are shown in Table 3.

Table 3 Percentage utilization[a] of residues

	Lupins	Beans	Soybeans	Sunflower	Sorghum	Maize
Grain						
Seasons 1 & 2	100	100	100	100	100	100
Straw						
Season 1	57,1	79,0	57,5	60,8	45,0	38,1
Season 2	37,4	75,6	55,6	61,7	57,2	9,3
Average	47,3	77,3	56,6	61,3	51,1	23,7
Weeds						
Season 1	93,4	97,6	100	100	100	100
Season 2	95,8	100	100	100	47,1	80,0
Average	94,6	98,8	100	100	73,6	90,0
Total						
Season 1	70,3	83,6	59,8	63,9	47,3	43,7
Season 2	52,3	81,6	59,2	62,8	56,9	21,1
Average	61,3	82,6	59,5	63,4	52,1	32,4

[a] % Removed.

In the present context, the term utilization includes losses of material due to weathering, wind and trampling. No estimate of the extent of such losses was obtained, but according to Schoonraad (1985) such losses are relatively small (about 11%) on harvested maize residues. Henning & Steyn (1984) found weathering of 36% on dry maize plants after four weeks. No figures are available on the other residues.

Excluding weeds, the percentage utilization of total dry matter was most in the case of dry beans (average 82,6%) and least in the case of maize (32,4%). In comparison, Van Pletzen (1983) recorded a percentage removal of 36% for maize residues and Schoonraad (1985) recorded 45%. Utilization of lupins, soybeans and sunflower was in the order of 60%. The utilization of 50% of sorghum corresponds with the 49% found by Powell (1985).

No grain remained on any of the lands after grazing. Van Pletzen & Oosthuizen (1984) also reported a 100% utilization of maize grain. However, because an unknown proportion of the grain was consumed by birds, it cannot be assumed that all grain was available to the sheep. Also, it is likely that some grain was trampled into the soil and was therefore not available to the sheep.

In both seasons weeds were well utilized and, except for the sorghum land in Season 2 where only 47% was utilized, utilization varied between 80 and 100%. The low level of utilization on the sorghum land can probably be attributed to the presence of unpalatable annual grasses.

Grazing period

The grazing period was noted from the start of grazing until the average sheep mass was the same as the initial average mass. Grazing periods for the different crop residues are shown in Table 4.

Table 4 Length of grazing periods (days) for the different crop residues

Grazing period	Lupins	Beans	Soybeans	Sunflower	Sorghum	Maize
To max. mass						
Season 1	49	50	63	59	77	63
Season 2	34	27	76	41	41	48
Average	42	39	70	50	59	56
Total						
Season 1	135	63	126	140	112	140
Season 2	69	41	104	83	104	76
Average	102	52	115	112	108	108

The length of grazing periods differed markedly between seasons. Total grazing periods were longer in Season 1 than in Season 2 as a result of the greater amount of DM available.

In Season 1 the longest grazing period to maximum mass (77 days) was obtained with sorghum and in Season 2 with soybeans (76 days). The grazing periods on the other residues within each season were very similar.

The grazing period on lupins to attain maximum mass was 49 days. Croker *et al.* (1979) correspondingly found a mass increase up to day 77 with a stocking rate of 16,7 sheep/ha. The available DM in this study was much less than their 6—9 t DM/ha. According to Croker *et al.* (1979), Merino wethers will show a mass increase for a period of 9—10 weeks at a stocking rate of 25 sheep/ha if more than 5 t DM/ha is available.

In this study, 10 sheep/ha grazed maize residues for between 7 and 9 weeks with a mass increase. This corresponds with the results of Van Pletzen (1981) who found that maximum mass for stocking rates of respectively 6, 9 and 12 sheep/ha was reached after 8, 7 and 6 weeks on maize residues.

Total grazing periods varied markedly between crops and seasons. In Season 1, sheep on sunflower, maize and lupin

residues had the longest total grazing periods, namely 140, 140 and 135 days respectively. The 10 sheep/ha in this study grazed the maize residues for 140 days. Van Pletzen & Oosthuizen (1984) found a grazing period of 105 days with a stocking rate of 6 sheep/ha. In Season 2, the longest grazing periods were on soybean and sorghum residues, namely 104 days each. In both seasons dry beans had the shortest grazing period, namely 63 and 41 days for Seasons 1 and 2 respectively. However, because of early availability, dry beans can be utilized during the crucial period of autumn and early winter. The length of grazing period was mainly dependent on the quantity DM that remained on the lands after harvesting, especially the amount of grain.

In Figure 1 it is shown that the crop residues became available at different times in the autumn and early winter and can thus be regarded as complementary in respect of fodder flow. However, the time they become available may vary widely between seasons as a result of the moisture content of the grain that has to be harvested. Hence, in some seasons residues might not be available when needed. It is therefore important to make provision for extra feed in case of such a possibility.

Mass changes of sheep

Mass gains of sheep to maximum mass on the different crop residues are given in Table 5 and the relative mass changes for the whole grazing period are shown in Figure 2. In the case of dry beans in Season 2, the sheep actually lost mass throughout the grazing period.

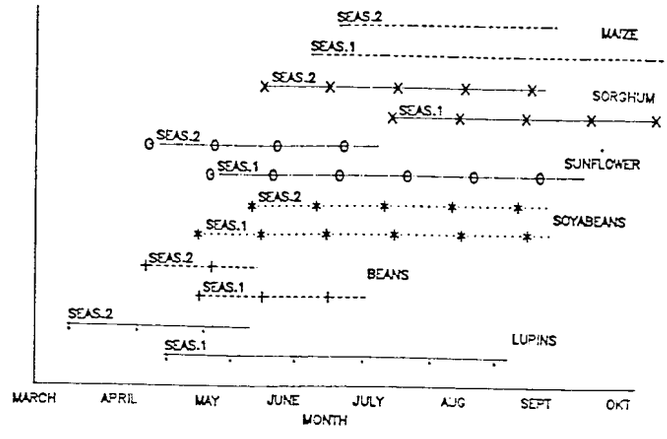

Figure 1 Periods during which the crop residues were available.

In spite of adaptation, the sheep temporarily lost mass in both seasons after being introduced to the residues. Those on lupin and maize residues, however, adapted quickly and regained their initial mass after two to three weeks. A similar loss was recorded by Ueckermann *et al.* (1980) for sheep grazing soybean residues.

The grazing period to attain maximum mass differed between crops and seasons, and can largely be ascribed to differences in the amount and quality of the residues available. In Season 1, sheep on lupin residues had the highest ADG, namely 130 g. In this season 0,21 t lupin grain/ha and 0,76 t weeds/ha were available. The highest

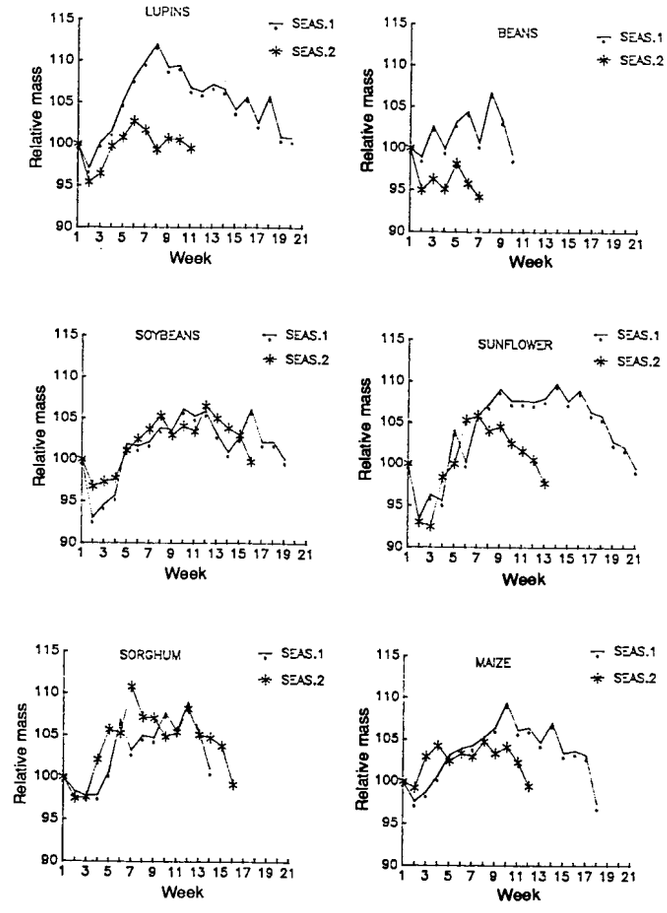

Figure 2 Relative mass changes of sheep over the grazing periods.

Table 5 Mass increase to maximum mass and average daily gain for sheep grazing crop residues

	Lupins	Beans	Soybeans	Sunflower	Sorghum	Maize	± *SE*	Differences
Mass increase (kg)								
Season 1	6,3	3,4	3,1	4,6	4,5	5,3		
Season 2	1,5	−1,0	3,4	3,1	5,6	2,6		
Average	3,9	1,2	3,3	3,9	5,1	4,0		
ADG (g)								
Season 1	130	67	48	79	59	87	37,8	1>3,5
Season 2	44	−37	45	76	137	54	52,6	4,5>2
Average	87	15	47	78	98	71		

Table 6 Wool data of sheep on crop residues

	Lupins	Beans	Soybeans	Sunflower	Sorghum	Maize	± *SE*	Differences
Clean yield percentage	60,14	62,27	60,31	62,90	60,23	63,31	5,61	NS
Wool growth rate (g/100 cm^2/d)	0,53	0,26	0,28	0,28	0,28	0,24	0,06	1>2,3,4,5,6
Fibre diameter (μ)	22,43	20,60	19,37	20,61	19,81	20,23	1,47	1>3,5

ADG in the second season was on sorghum residues, namely 137 g. In Season 2, sheep on dry beans lost mass as a result of the small amount of only 1 t DM/ha available.

In both seasons the ADG of sheep on soybean residues was poor, namely 48 and 45 g respectively. This is much lower than the 85 g for wethers reported by Ueckermann *et al.* (1980). The quantity of grain on the soybean lands was comparable for both seasons. Less weeds were available on the soybean land which may partially explain the low ADG.

The growth performances realized on residues of lupins, sunflower, sorghum and maize suggest that these residues have higher potential than dry bean and soybean residues. However, seasonal differences may be vast.

Wool production

Clean yield percentages, wool growth rate and fibre diameter of the wool for the sheep grazing the different crop residues in Season 2 are presented in Table 6.

The clean yield percentage of samples was very similar for all crops, being on average 61,5%. The figure is appreciably lower than the *c.* 70% commonly recorded for sheep grazing on veld in the local environment (Dept. Agriculture and Water Affairs, Progress Report, 1988). Ueckermann *et al.* (1980) recorded a clean yield percentage of 54% for sheep grazing soybean residues, suggesting dust infiltration when grazing crop residues.

Wool growth rate on all crops except lupins was similar and varied from 0,24—0,28 g/d/100 cm^2. Wool growth rate on lupins was significantly ($P \geq 0,05$) higher than on other crops, namely 0,53 g/d/100 cm^2. Similarly, fibre diameter was significantly greater on lupins than on soybean and sorghum residues, probably as a result of higher protein and energy intake as shown in the second paper. (Esterhuyse *et al.*, 1991).

Conclusions

The amount and composition of the crop residues discussed may differ between seasons as a result of cultivar, climate, locality, rainfall, length of time and degree of weathering between harvest and grazing, the efficiency with which the grain is harvested and in the case of susceptible crops, bird damage. The figures presented provide therefore, only a rough indication of the differences in composition, quality and degree of utilization by sheep.

The results underline the importance of grain and, to a lesser extent, weeds in the diet of grazing sheep. Hence, inefficient harvesting and to a degree poor weed control, though undesirable in terms of crop production, are beneficial to sheep. Winter rain also results in weed regrowth, thus increasing the nutritional value of the residues.

It is desirable that crop residues be grazed as soon as possible after harvesting, before weathering starts. The finer parts may blow away and the grain can be utilized by birds and rodents.

For periods of 4 to 11 weeks, ADGs of between 45 and 140 g can be attained by sheep grazing the six crop residues evaluated in this study. However, the actual level of gain is to a large extent unpredictable. In part, the unpredictability can be attributed to the presence of appreciable amounts of weed and the quality and quantity thereof as affected by weather conditions before and during the grazing periods.

The total length of the grazing period between seasons differed widely, but not between different crop residues, except for dry beans where the grazing period was markedly shorter. Differences are to be found between seasons because the amount of material may differ vastly from season to season.

It is apparent that crop residues may be an economic means of maintaining mass. Clean yield percentages of wool though, may be lower, but this should be of minor concern in relation to the low cost of wintering sheep in this way.

Acknowledgements

The authors thank Mr G. van der Linde for planting the crops, Mr J.H. van der Walt, Mrs H. Swiatek and Elias Mkhwanazi for chemical analysis and Mr D.L. Barnes for constructive criticism of the paper.

References

ARNOLD, G.W., CHARLICK, A.J. & WALLACE, S.R., 1976. Comparison of crops of lupins, peas and vetches for weaner sheep in summer in a Mediterranean environment. *Proc. Aust. Soc. Anim. Prod.* 11, 361.

CARBON, B.A., ARNOLD, G.W. & WALLACE, S.R., 1972. The contribution of lupin seed to the performance of animals grazing Uniwhite lupins. *Proc. Aust. Soc. Anim. Prod.* 9, 281.

CROKER K.P., ALLEN, J.G., PETTERSON, D.S., MASTERS, H.G. & FRAYNE, R.F., 1979. Utilization of lupin stubbles by Merino sheep: Studies of animal performance, rates and time of stocking, lupinosis, liver copper and zinc, and circulating plasma enzymes. *Aust. J. agric. Res.* 30, 551.

DEPT. AGRICULTURE AND WATER SUPPLY, 1988. 'n Vergelyking van verskillende kombinasies van sojabone en geel mielies as byvoeding by die oorwintering van wolskape op gespaarde veld. Faset T5312/05/2/4, Nooitgedacht-navorsingstasie.

ESTERHUYSE, C.D., NIEMAND, S.D. & MEISSNER, H.H., 1991. Feeding potential of summer grain crop residues for woolled sheep in the south-eastern Transvaal Highveld. II. Selection of material and intake. *S. Afr. J. Anim. Sci.* 21, 149.

HENNING, P.H. & STEYN, D.G., 1984. The response of different portions of the maize plant to NaOH treatment. *S. Afr. J. Anim. Sci.* 14, 142.

POWELL, J.M., 1985. Yields of sorghum and millet and stover consumption by livestock in the subhumid Zone of Nigeria. *Trop. Agric. (Trinidad)* 62, 77.

SCHOONRAAD, H.M.I., 1985. Oorwintering van skape op gestroopte mielielande. Inligtingsweek oor veeproduksie-aangeplante weidings. Nooitgedacht-navorsingstasie, Ermelo. Departement van Landbou en Watervoorsiening.

UECKERMANN, L., NEL, P.N.A. & NIEMAND, S.D., 1980. Die bepaling van die drakrag van gestroopte teenoor ongeoeste sojaboonlande vir die oorwintering van skape. Nooitgedacht-navorsingstasie. Ongepubliseer.

VAN PLETZEN, H.W., 1981. Oorwinter skape op afgeoeste mielielande. *Goue Vag* April, 12.

VAN PLETZEN, H.W., 1982. Afgeoeste mielielande goedkoopste manier van oorwintering. *Goue Vag* Maart, 10.

VAN PLETZEN, H.W., 1983. Benutting van verskillende ruvoer bronne vir die oorwintering van skape. *Die O.T. Kaner* Junie, 13.

VAN PLETZEN, H.W. & OOSTHUIZEN, W.T., 1984. Roughage in the winter feeding of sheep. *Golden Fleece* May, 36.