

The potential of maize crop residues for wintering sheep on the eastern Transvaal Highveld

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Maize crop residues were grazed at three stocking rates, viz. 6, 9 and 12 sheep/ha, for about three months. Total DM yield of the maize crop was about 7 500 kg/ha, and consisted of 38,5% grain and 61,5% residues. During harvesting, an average of 338 kg grain/ha was wasted. On average, crop residues consisted of 49% leaves, 31% stems, 3,5% cob leaves, 10% cobs and 6,7% grain. About 39% of the crop residues was removed during the grazing period. Weathering accounted for 21% loss of residual material on an adjacent site that was not grazed. Grain and finer leaf material were almost totally utilized, and oesophageal samples contained between 80 and 90% grain during the first four weeks of grazing. Thereafter, grain content fell sharply, with nutrient and energy content following suit. Stocking rate did not affect mass gains significantly ($P \leq 0,05$), but wool growth declined significantly with an increase in stocking rate. Nevertheless, these production parameters were higher with a stocking rate of 12 sheep/ha than with stocking rates of 6 and 9 sheep/ha, when production was calculated per hectare. Production levels were judged to be highly satisfactory, from which it was concluded that sheep may be successfully wintered for up to 1 250 sheep grazing days.

Mielie-oesreste is teen drie veeladings van onderskeidelik 6, 9 en 12 skape/ha vir ongeveer drie maande bewei. Die totale DM-opbrengs van die mielieland was ongeveer 7 500 kg/ha, en het bestaan uit 38,5% graan en 61,5% reste. In die strooproses is gemiddeld 338 kg graan/ha vermors. Die oesreste het bestaan uit 49% blare, 31% stamme, 3,5% kopblare, 10% stonke en 6,7% graan. Gedurende die weiperiode is ongeveer 39% van die reste verwyder. Waar die reste nie bewei is nie, het 21% verweer en verdwyn. Die graan en fyner blaarmateriaal is feitlik totaal benut, en slukdermonsters het getoon dat 80 tot 90% van die geselekteerde materiaal in die eerste vier weke van beweiding, graan was. Daarna het die graaninhoud skerp gedaal en gevolglik ook die nutriënt- en energie-inhoud. Veelading het nie massatoename betekenisvol ($P \leq 0,05$) beïnvloed nie, maar wolproduksie het betekenisvol verlaag met 'n toename in veelading. Nietemin was dié twee produksieparameters, bereken op 'n per-hektaarbasis, hoër in die geval van 'n veelading van 12 skape/ha as in die geval van veeladings van 6 of 9 skape/ha. Die produksies wat verkry is was hoogs bevredigend, en die gevolgtrekking is gemaak dat skape suksesvol vir 1 250 skaap-weidag oorwinter kan word.

Keywords: Maize residues, grazing, stocking rate, oesophageal samples, mass gains, wool production.

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Introduction

Wintering remains an area of major concern with regard to animal production in the eastern Transvaal Highveld, mainly because feed production is largely seasonal. Being essentially a summer rainfall area, occasional winter rainfall is insufficient for successful cultivation of dryland winter pasture. The provision of quality forage for the winter is further complicated by the nutritional value of sour grass veld which plummets in the

autumn and winter (Rethman, 1984). In fact, the production, palatability and nutritional value of the veld drop to such an extent that sheep cannot be wintered satisfactorily. A solution is to provide supplementary feeding (Barnard, 1976; Dreyer, 1980; Bekker & Stoltz, 1983). However, the cost of supplementary feeding may decrease profitability. Consequently, it is preferable to carry over forages produced in summer and/or use residues of summer cash crops.

Much is known about transferable forages such as silage (Van der Merwe *et al.*, 1977; Giliomee, 1984) and hay, of which *Eragrostis curvula* is the most abundant in the region (Eeden & Beukes, 1984). In comparison to maize residues, transferable forages are relatively expensive. Therefore it is more acceptable to winter sheep on maize residues, provided that these residues are of acceptable nutritional quality.

Maize residues are usually collected mechanically and knowledge of the nutritional value, with or without alkali treatment, has been accumulated on a wide front (Berger *et al.*, 1979; Bertelsen, 1981; Hofmeyr *et al.*, 1981; Reid & Klopfenstein, 1983; Seed, 1983). According to Snyman (1985) and Schoonraad *et al.* (1987), mechanically collected maize residues are suitable for maintenance of ruminants, only when amply supplemented with nitrogen and phosphorus. This is not surprising, because the material collected by raking and baling consists mainly of stems and stem leaves which are of lower nutritional value than the grain and finer cob leaves (Henning & Steyn, 1984) which often remain on the land.

One of the aims of this study therefore was to determine the nutritional value of maize crop residues as selected by grazing sheep. Because of the expected higher quality of material selected by sheep compared to material collected by hand (Brendon *et al.*, 1967; Engels & Malan, 1973; De Waal, 1979), it was expected that sheep would show some increase in mass and wool growth. This would make the practice of grazing maize crop residues highly economical, as shown by Lamm *et al.* (1977).

Further aims of the study were to determine the amount of residue available for grazing, the amount actually utilized, the applicable carrying capacity and to establish whether stocking rate has an effect on animal production.

Procedure

Terrain

The study was conducted at Wildebeesfontein, the experimental farm of the Eastern Transvaal Co-op, in the Middelburg district. The long-term, average annual rainfall is 727 mm (Botha *et al.*, 1985) and is concentrated in the summer months, with the highest precipitation occurring during November, December and January. The precipitation during the year of study (1981/82) was lower (558 mm) than the long-term average, but the distribution corresponded well with normal patterns.

The yellow maize cultivar, SSM72, was planted in October 1981 in rows 0,91 m apart on a medium-potential Glencoe soil with a clay percentage of 20. On November 28 and December 13 of 1981, hail damaged the crops to the extent that 38 and 12% of the grain respectively, was lost (stratified, randomized survey). Whereas it is difficult to judge whether the hail damage actually affected the outcome of this study, results from other studies examined in the Discussion section showed similar patterns. Also, the occurrence of hail in this particular area is more the rule than the exception, which adds credibility to the practical application of the results.

The crop was harvested in May 1982. Maize cobs not retrieved by the harvester were collected by hand. Grain yield averaged 2,95 t/ha (14% moisture), which is equivalent to 2,54 t DM. This value is lower than the long-term average, probably because of lower rain and hail damage than normal.

An area of approximately 6 ha in the centre of the maize field was used to study carrying capacity and animal performance. This area was divided into six camps, each of one

hectare, with fencing erected according to a gradient of 3,3%. An adjacent area of 1,95 ha was also fenced and used to study selection by oesophageally fistulated sheep.

Measurement of residue yield and composition

Yield was determined in all camps before grazing, using six stratified, randomized, (3,64 × 2,47 m²) rectangles per camp. The side of 3,64 m was deliberately chosen, because the maize was planted by a four-row planter in 0,91-m rows and reaped with a four-row harvester, which is general practice in the Eastern Transvaal. Normally, this would give a plant density of 30 000 to 35 000 plants per hectare and a grain yield of 3 t/ha.

The residues were divided into leaves, cob leaves, stems, cobs and grain. After weighing each component separately, the residues were reconstituted and returned to the respective camps. Yields were estimated again at the end of the grazing period, using a neighbouring camp (1,14 ha) which had not been grazed, in order to estimate decay and loss by natural means.

Samples were collected by hand from the camps that were grazed at the beginning and end of the grazing period. These were analysed for nitrogen, crude fibre, ether extract, ash, P, Ca, Mg and K according to AOAC (1984).

Stocking rate and trial animals

A carrying capacity that is generally accepted in the Eastern Transvaal from crops that yield about 3 t grain/ha is 6 sheep/ha for 3—4 months. This capacity translates to 540—730 grazing days per sheep. Although ill-defined, this figure was nevertheless chosen as a starting point to determine the eventual carrying capacities used in this trial.

In the carrying capacity trial, 54 two-tooth Merino wethers of between 34 and 41 kg were allocated at random to three treatments in two repetitions. The three treatments consisted of 6, 9 and 12 sheep/ha respectively. These sheep grazed the six one-hectare camps for a period of 105 days. On the adjacent 1,95 ha camp, 18 two-tooth Merino wethers weighing 31,0—38,5 kg, four of which were oesophageally fistulated, were allowed to graze for 91 days. This represented a stocking rate of 9,23 sheep/ha.

Before initiation of the trials, sheep were treated for internal parasites and were then introduced to the crop residues without previous adaptation to the diet. The sheep were weighed at the start of the trials and once a week thereafter, after being kept from feed and water overnight. All sheep were shorn with electric shears nine days before the start of the trials and again at the end. Wool samples were obtained from the mid-rib position and sent to the Fleece Testing Centre for analysis.

All sheep had free access to water and a salt lick without P.

Oesophageal extrusa collection

Oesophageal samples were collected from the start of the trial on a weekly basis. After removal of excessive moisture from oesophageal samples by pressing through cheesecloth, the samples were stored in plastic bags in a deep-freeze. Samples were eventually dried in an extrusion oven at 60°C and were then divided into grain and roughage fractions. The components were weighed separately, reconstituted, ground, and stored in glass bottles with screw tops up to analysis.

The samples were analysed for nitrogen, crude fibre, ether extract, ash and Ca according to standard procedures (AOAC,

1984). The *in vitro* digestibility of OM was also determined by the method described by Tilley & Terry (1963), but the results proved to be unreliable during the first six weeks when the grain component of oesophageal extrusa was high. Total digestible nutrient (TDN) content was consequently calculated from regression equations calculated by Kears (1982) for sheep, as follows:

1. For energy-rich feedstuffs with less than 20% crude protein and 18% crude fibre:

$$\text{TDN \%} = 2,6407 + 0,6964 \text{ crude protein \%} + 0,9194 \text{ nitrogen-free extract \%} + 1,2159 \text{ ether extract \%} + 0,1043 \text{ crude fibre \%}$$

2. For roughages which contain more than 18% crude fibre:

$$\text{TDN \%} = -14,8356 + 1,3310 \text{ crude protein \%} + 0,7923 \text{ nitrogen-free extract \%} + 0,9787 \text{ ether extract \%} + 0,5133 \text{ crude fibre \%}$$

Statistical analysis

Crop-residue yield and animal production data were analysed according to a randomized block design by GLM procedure, using Tukey's test. The chemical composition of crop residues was not statistically analysed, but the standard deviations were calculated and presented with the means. Similarly, because there was only one stocking rate in the selection trial, only data means and standard deviations were calculated, and presented accordingly.

Results and Discussion

Crop residue yield

The crop residue yields before and after grazing are shown in Table 1.

Table 1 Crop residue yield and the amounts removed during grazing (kg DM/ha)

	Component					Total
	Leaves	Stems	Cob leaves	Cobs	Grain	
Yield						
Six sheep/ha	2393	1597	211 ^c	609	380 ^b	5189 ^b
Nine sheep/ha	2092	1487	119 ^a	362	270 ^a	4330 ^a
Twelve sheep/ha	2566	1662	174 ^b	519	364 ^b	5286 ^b
MSD*	299	193	33	118	50	358
Selection trial	2809	1428	197	573	336	5343
Removed						
Six sheep/ha	868 ^y	189 ^x	181	316	379 ^y	1933 ^y
Nine sheep/ha	89 ^x	565 ^y	105	123	267 ^x	1149 ^x
Twelve sheep/ha	838 ^y	678 ^y	165	212	363 ^y	2255 ^y
MSD	350	183	39	116	50	446
Selection trial	1363	586	178	161	335	2623

^{a, b, c, x, y} Values in the same column with different superscripts differ significantly ($P \leq 0,05$).

* Mean standard deviation.

The total DM yield before harvesting was about 7500 kg/ha, which consisted of 38,5% grain and 61,5% residues. According to Dreyer (1980), residues should make up 54,5% of the total yield of a maize land which yields 2500 kg grain/ha. Lamm & Ward (1981) found that, with a relatively high grain yield of 5000 kg/ha, the residue component constituted 55,2% of the total yield. In general, it appears that the residue component is usually larger than the grain component, but the difference may vary depending on grain yield as well as cultivar, soil type and climatic conditions.

During harvesting, an average of 338 kg grain/ha was wasted, although the value on the camps with a stocking rate of 9 sheep/ha was significantly lower. The total yield of residues on these camps, however, was also lower than on camps with a stocking rate of 6 and 12 sheep/ha (Table 1); an unexpected result. A wastage of 11,5% of grain yield (2950 kg/ha) was recorded, which is higher than the 8,9% reported by Swart *et al.* (1983) with a grain yield of 3490 kg/ha, and the 6,8% reported by Schoonraad (1985) when the grain yield was 7400 kg/ha. Thus, it appears that the percentage wastage was higher with lower grain yields. A possible explanation for this observation is that, in general, smaller kernels are found with lower grain yields and these grains are not collected as effectively by a harvester as the heavier kernels. There may be other explanations such as the efficiency of grain collection by the harvester, as reported by Lamm & Ward (1981), who found a relatively high grain wastage of 13,8% when the grain yield was 5000 kg/ha.

On average, crop residues consisted of 49% leaves, 31% stems, 3,5% cob leaves, 10% cobs and 6,7% grain, with little difference between treatments, despite the significantly lower yield (Table 1) obtained from the treatment of 9 sheep/ha. This yield of leaves is somewhat more than those quoted by Lamm & Ward (1981) and Schoonraad (1985), which may be partially explained by the hail damage. Lamm & Ward (1981) determined the composition to be 39% leaves, 41% stems, 9,1% cobs and 11% grain, while Schoonraad (1985) reported a composition of 40% leaves, 31% stems, 22% cobs and 6,5% grain. Leaves and stems clearly constituted the largest portion of maize crop residues, followed by cobs and grain.

There was no significant difference in the amount of cobs and cob leaves removed (Table 1). Cob leaves, in fact, were almost totally utilized, as was grain. This corresponds to the results of Esterhuysen (1990). Less stems were removed at a stocking rate of 6 sheep/ha ($P \leq 0,05$), while less leaves were removed at the stocking rate of 9 sheep/ha. On average, the residues removed from the total area were 32% leaves, 33% stems, 90% cob leaves, 39% cobs and 99,5% grain. Of total residues, about 39% were removed with relatively small differences between treatments. By comparison, values from the literature vary between 32 and 36% (Weber *et al.*, 1970; Swart *et al.*, 1983; Schoonraad, 1985; Esterhuysen, 1990). It appears therefore, that no more than 40% of residues is utilized under normal grazing conditions when realistic stocking rates are employed.

It is not clear whether this selective removal of residues will influence future grain production. According to Koster *et al.* (1987), the average grain yield over eight years on sites where residues were totally removed, was 4780 kg/ha compared to 4940 kg/ha where residues were not removed. No significant fluctuations in annual grain production were recorded during this period. It can thus be concluded that grazing of maize

residues at realistic stocking rates of up to 12 sheep/ha would probably not be detrimental to future grain production.

Observations on the neighbouring ungrazed (control) site are shown in Table 2.

Table 2 Crop residue yield on the control site (kg DM/ha)

Component	10 June	23 September	Decayed or lost (%)
Leaves	1554 ± 630*	1107 ± 736	447 (29)
Stems	1332 ± 330	1259 ± 371	73 (5)
Cob leaves	186 ± 97	131 ± 82	55 (30)
Cobs	410 ± 235	310 ± 205	100 (24)
Grain	352 ± 178	218 ± 224	134 (38)
Total	3834 ± 951	3025 ± 1413	809 (21)

* Standard deviation.

After a period of 105 days (10 June—23 September), 21% of the residues had disappeared, whereas the percentages for the readily perishable components, such as leaves, were higher. Lamm & Ward (1981) reported a decay and disappearance of 37% over an 86-day period during which snow had fallen. Schoonraad (1985) found a decay of 11% after 91 days. It thus appears that a relatively large percentage of residues is lost as a result of wind and decay.

Chemical composition of residues

The chemical composition of samples collected by hand, before and after grazing, is shown in Table 3.

The results from carrying capacity and the selection study corresponded fairly well. Also, the chemical composition of residues from the different camps and replications of the carrying capacity study did not differ either before or after grazing (see MSD values in Table 3). Crude protein content

Table 3 Chemical composition of residues collected by hand before and after grazing (% of DM)

	Item							
	Crude protein	Ether extract	Crude fibre	Ash	P	Ca	Mg	K
Before								
Six sheep/ha	6,80	0,91	34,7	6,38	0,13	0,44	0,28	1,04
Nine sheep/ha	6,88	1,23	35,3	6,36	0,14	0,51	0,29	0,91
Twelve sheep/ha	6,54	0,88	32,0	6,03	0,12	0,48	0,27	0,98
MSD*	0,81	0,23	6,43	1,89	0,03	0,08	0,02	0,14
Selection trial	6,02	1,09	31,6	5,23	—	0,44	0,28	0,92
After								
Six sheep/ha	5,40	0,66	—	—	0,17	0,54	0,25	0,68
Nine sheep/ha	5,18	0,71	—	—	0,17	0,60	0,24	0,56
Twelve sheep/ha	5,01	0,66	—	—	0,16	0,59	0,25	0,61
MSD	0,81	0,23	—	—	0,02	0,11	0,02	0,17
Selection trial	5,05	0,46	—	—	—	0,58	0,26	0,70

* Mean standard deviation.

decreased by about 1% and the ether extract by 0,5% during the grazing period. By contrast, the mineral contents remained approximately the same, with some evidence of a possible increase in Ca.

However, it should be borne in mind that, because these samples were collected by hand, the composition reported here was not necessarily representative of the diet that would have been selected by the sheep. The composition should rather be seen as representative of the total available residues. The chemical composition of material actually selected by oesophageally fistulated sheep is presented in Table 4.

Table 4 Percentage grain and chemical composition of oesophageal extrusa (% of DM), and the estimated total digestible nutrients (TDN) over 91 days of grazing

Week	Grain	Crude protein	Ether extract	Crude fibre	Ash	Ca	TDN
0	89,2	8,59	3,81	1,95	2,69	0,18	89,7
1	92,8	7,72	3,85	3,36	3,67	0,17	87,9
2	81,7	7,81	3,41	3,95	4,84	0,18	86,2
3	88,4	7,81	3,66	3,25	4,21	0,16	87,4
4	81,6	7,96	3,36	4,79	4,05	0,18	86,2
5	74,0	8,55	3,71	5,29	5,31	0,25	83,6
6	55,5	8,25	2,57	9,77	7,16	0,24	74,0
7	22,6	7,47	1,75	17,8	9,97	0,40	63,8
8	12,4	6,35	1,16	22,5	10,5	0,46	53,3
9	9,3	5,66	1,12	21,6	12,2	0,43	52,0
10	6,2	5,42	0,94	20,2	13,0	0,36	51,6
11	1,9	5,63	0,88	24,7	10,9	0,40	52,1
12	4,1	6,05	0,91	22,9	12,0	0,44	51,9
13	0,6	6,40	0,81	17,3	18,3	0,44	48,7
MSD*	7,28	0,80	0,41	3,06	2,36	0,09	2,85

* Mean standard deviation.

Examination of the contents of oesophageal extrusa showed that the sheep had selected mainly grain during the first 4—5 weeks of grazing (Table 4). The high grain fraction is cause for concern because of the probability of acidosis. Therefore, it is advisable to adapt sheep to concentrate feeding before they are introduced to maize crop residues. After six weeks of grazing, grain was still selected in substantial portions but, from nine weeks onwards, oesophageal extrusa consisted mainly of roughage material.

Because of the high grain content during the early grazing period, the chemical composition and energy content of extrusa samples corresponded to the chemical composition of maize grain (Table 4). As from about week 5, the crude protein content declined from ca. 8 to 5 or 6% where it stabilized. A level of 5—6% may be marginal for effective fermentation (Mirson, 1977). Pregnancy toxemia is often encountered in heavily pregnant ewes on crop residues. From the present results, it is clear that energy would not have been limiting in this trial, at least during five to six weeks of grazing. However, because nitrogen may be marginal, ineffective fermentation may have prohibited maximal DM intake. Therefore it is suggested that maize crop residues fed to pregnant ewes should be supplemented with nitrogen. This was also proposed by Esterhuysen (1990).

Ether extract and TDN gradually decreased as the content of roughage material increased (Table 4). In contrast, crude fibre, ash and Ca increased later during the grazing period. The high ash content towards the end of the grazing period may have been due to the ingestion of large amounts of soil. The sheep may have continued to seek out grain particles when none were left. It was observed that the soil was often scraped away with a hoof in an effort to find grain.

In comparing Tables 3 and 4, it is evident that the composition of hand-collected samples differed vastly from oesophageal samples and that the sheep managed to select a diet of much higher quality than that available from the crop residue, on average, during the first seven weeks.

Animal production

Mass gains, wool production and physical characteristics of wool during the grazing period are shown in Table 5.

Stocking rate did not influence mass gains significantly, although there might have been a tendency for mass gains to decline with stocking rate. Surprisingly, values for mass gains in the selection study were much higher. While the reason for this is not clear, sheep in that study utilized more leaves (Table 1). In this particular investigation, it was noticed that daily gains of 261 g were recorded during the first four weeks when grain was readily available. This value declined to 32 g between weeks 5 and 11 when grain availability declined sharply, and to about 0 g during the last two weeks. It is evident, therefore, that the maize residues sustained a reasonable degree of mass gain, even at a stocking rate of 12 sheep/ha, over a period of at least three months.

The different stocking rates convert to between 630 and 1260 grazing days per sheep. The arbitrarily recommended carrying capacity standard for the Eastern Transvaal of 540—720 sheep grazing days therefore appears to be conservative, even if potential hail damage to the crop is taken into account.

The sheep produced 46,5, 59, and 69 kg live mass/ha at stocking rates of 6, 9, and 12 sheep/ha, respectively. A much higher gain of 103 kg/ha was obtained in the selection trial where the stocking rate was 9,23 sheep/ha. Schoonraad (1985) reported mass gains of 7 kg per sheep with a stocking rate of 8 mature Döhne Merino wethers/ha over a period of 91 days. This represents a carrying capacity of 728 sheep grazing days and a live mass gain/ha of 56 kg, which corresponds with the

lower figures of this study. Weber *et al.* (1970) found mass gains of 10,5 kg and 23,6 kg per animal for cows and heifers respectively, over a 100-day grazing period. According to these authors, a realistic stocking rate for the winter period should be 0,8 cows/ha which, in South-African terms, would correspond to roughly one large stock unit (LSU)/ha.

Clean fleece mass was highly significantly ($P \leq 0,01$) decreased by increasing the stocking rate (Table 5). However, this was not the case when results were expressed in terms of wool production/ha. Productions of 8,2, 11,5, and 14,0 kg/ha were calculated for the stocking rates of 6, 9, and 12 sheep/ha, respectively. A yield of 13,3 kg/ha was calculated for the stocking rate of 9,23 sheep/ha in the selection trial. Schoonraad (1985) reported a greasy wool production of 1,04 kg per sheep for the Döhne Merino over 91 days, which converted into 9,6 kg/ha when calculated for the period of 105 days. These figures are comparable, bearing in mind the higher production expected of the Merinos that were used in this investigation.

If calculated on a daily basis, extremely satisfactory productions of 13,0, 12,2 and 11,1 g clean wool per sheep for the stocking rates of 6, 9 and 12 sheep/ha respectively, were obtained. In the case of the selection study, the yield was even more (15,8 g). By comparison, Van der Merwe (1982) reported that seven Merino flocks, kept under a fairly high level of nutrition, produced on average 12,6 g clean wool per day, while De Klerk *et al.* (1983) concluded that the average greasy wool production per sheep in South Africa was 15,4 g/d (about 10 g clean wool). These figures emphasize that maize crop residues grazed over a three-month period may ensure a more than adequate wool production.

The physical characteristics of the wool suggest that, at all stocking rates tested, wool quality was highly acceptable (Table 5). The significant ($P \leq 0,05$) decline in fibre diameter with stocking rate, in fact, is advantageous under current economic conditions. Staple length also tended to decline with stocking rate, but the results were not significant. According to Visser (1985), staple lengths of 75—90 mm for wool grown over 12 months are acceptable, which suggests that performance in this trial exceeded normal expectations.

Excessive dust penetration of wool may result when sheep graze maize crop residues, to the detriment of processing costs because of lower clean yield (Visser, 1982). The results,

Table 5 Mass gains, wool production and physical characteristics of wool during the grazing period

	Item					
	Mass gains (kg/sheep)	Clean fleece yield (kg./sheep)	Clean fleece (%)	Fibre diameter (micron)	Staple length* (mm)	Crimp deviation (index)
Six sheep/ha	7,75	1,37 ^c	62,5	22,8 ^b	108	95,8
Nine sheep/ha	6,56	1,28 ^b	63,0	21,1 ^a	102	91,6
Twelve sheep/ha	5,75	1,17 ^a	63,2	20,8 ^a	99,3	90,4
MSD**	0,90	0,07	1,80	0,71	5,24	2,69
Selection trial	11,1	1,44	—	21,7	110	—

^{a-c} Values in the same column with different superscripts differ significantly ($P \leq 0,05$).

* Staple length was adjusted proportionally to 365 days wool growth.

** Mean standard deviation.

however, showed no significant differences in clean fleece percentage between stocking rates (Table 5), and the recorded percentages of about 63% were comparable to the 63,3% recorded by Esterhuysen (1990) on maize residues and the average of 64,2% calculated for 1017 samples by the Fleece Testing Centre (Erasmus & Delpont, 1987). These samples were considered to be fairly representative of the national wool clip.

Overall, the animal production data obtained from a stocking rate of 9 sheep/ha is in line with the production data obtained from stocking rates of 6 and 12 sheep/ha (Table 5). This suggests that the significantly lower availability of residues for this treatment (Table 1) was not a limiting factor in realizing comparable levels of animal production.

Conclusions

It is generally accepted that the residue component from a maize crop is approximately equal in mass to the grain yield but, from this and other studies, it is clear that the residue component is usually larger. Leaves and stems constitute the major portion of this residue followed by the contribution from cobs, grain and cob leaves.

Of the total residues, 39% was removed during the grazing period, which apparently includes losses due to weather conditions. Losses due to decay and other reasons may be substantial, as shown by the substantial loss of 21% measured on a neighbouring ungrazed camp over the same three-month period.

The finer leaf and grain components of the residues were almost totally utilized. In fact, analyses of oesophageal samples indicated that 80—90% of the material ingested consisted of grain with some fine leaf material during the first four weeks of grazing. A practical advantage of this preference for grain is that regrowth of maize in the next season is virtually eliminated.

Furthermore, analyses of oesophageal samples indicated that the nutritional value of maize residues selected by sheep was generally much higher than that of residues collected mechanically. This was supported by the satisfactory levels of mass gains and wool growth realized in this study, compared to reports which showed that collected residues were usually only barely sufficient for maintenance. The magnitude of the mass gains recorded in this investigation though, was very much a function of the availability of grain in the residues.

These results suggest that the carrying capacity of maize residues for the area may be higher than the accepted standard of 6 sheep/ha for three to four months. Although stocking rate significantly influenced production per animal, satisfactory production was still achieved at a stocking rate of 12 sheep/ha over a grazing period of 105 days. A grazing capacity of 1250 sheep grazing days on maize residues in the eastern Transvaal Highveld is thus possible, which elucidates the high potential of maize residues to winter sheep successfully and cheaply.

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