A STUDY OF THE EFFECT OF THINNING ON THE YIELD, COMPOSITION, PALATABILITY AND DIGESTIBILITY OF MARROW-STEM KALE

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by

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INTRODUCTION

Due to climate and other natural advantages, the livestock industry in New Zealand is based upon a pastoral economy. The large-scale use of grassland and its products, hay and silage, for feeding the livestock, gives the industry its low-cost production structure. However, one of the problems associated with this dependency upon grassland is that of fitting seasonal production of pasture to stock requirements. McMeekan (1952) has listed the methods through which the solution may be sought. One of these is the use of supplementary crops. Hadfield (1952) estimated that 75% of the million acres devoted to cropping in New Zealand was used to supplement pasture.

In late summer and autumn, two periods when pasture production is unreliable, one of the most suitable crops for the provision of supplementary fodder is marrow-stem kale. Evidence of this is afforded, at least in part, by the increased acreage of marrow-stem kale grown over the past few years. According to a supplementary report on the Farm Production Statistics of New Zealand (1954), 8000 acres of marrow-stem kale were grown in 1933, whilst by 1954, the acreage had expanded to 110,000.

There is a distinct paucity of published literature concerning marrow-stem kale, compared with that dealing with other crop species, possibly because it is a relative newcomer to agriculture; it was introduced to commerce at the beginning of this century. European authorities are responsible for the bulk of experimentation on this crop. Calder (1939, 1944) has

published data on marrow-stem kale trials in New Zealand. Robinson at Massey Agricultural College has also studied certain aspects of marrow-stem kale growth in recent years. The experiment, which is the subject of this thesis, was designed to add to existing knowledge of this crop under New Zealand conditions.

Experimental work was undertaken to determine the effect of different thinning treatments on the yield, composition, palatability and digestibility of marrow-stem kale grown in rows.

C H A P T E R II

REVIEW OF LITERATURE

This review will be presented in three sections as follows:

(a) Literature relevant to the yield of marrow-stem kale, with special reference to the effect of thinning treatments.

(b) Literature dealing with the composition of marrow-stem kale.

(c) Literature concerning the palatability and digestibility of marrow-stem kale.

(a) Yield

One of the methods of expressing the productivity of a farm crop is that of yield in terms of green or dry matter weight per unit area. This method is most accurate when the whole crop is harvested at maturity or at some definite stage of growth. These yields can be further supplemented with an indication of nutritive value as determined by chemical analysis and perhaps digestibility trials. With marrow-stem kale, experiments have shown that the chemical composition of the leafage differs from that of the stem, so that in estimating the feeding value of the crop, the proportion of leaf to stem is important; the leafier the crop the higher will be the nutritive value.

Yield data from a series of trials on marrow-stem kale are set out in tabular form in Table I. Green matter yields were presented, because in the bulk of the literature reviewed, the dry matter yields were frequently not listed.

It would be invidious, perhaps, not to deal briefly with the effect of nitrogen fertilization on the yield of marrow-stem kale, since many of the aforementioned trials involved treatments at different levels of nitrogen manuring in conjunction with the effect of thinning. In general, experimental results consistently showed that yields of marrow-stem kale were increased by nitrogen fertilization. The reports only differed as regards the level of nitrogen manuring beyond which no further economic yield response was forthcoming. This point was probably governed by climatic, soil or biological factors.

Table I

Summary of Data in the Literature for Green Matter Yields[1] (Tons) of Marrow-stem Kale, Unthinned and Thinned

Authority	Treatments		Green Matter Yields (Tons/acre)		Statistical Significance[2]
	Unthinned	Thinned	Unthinned	Thinned	
Rothamsted Ann.Rep.					
1932 a	Unthinned	18" apart	26.58	24.40	S
1932 b	4" apart	12" apart	25.16	24.01	NS
1933 a	Unthinned	18" apart	13.05	10.23	S
1933 b	1" apart	12" apart	33.46	30.83	S
1934	Unthinned	Thinned	32.74	33.24	NS
1935	3-4plant bunches at 6" apart	9-10" apart	35.73	34.52	NS
1936	Unthinned	5-6"apart where weeds abundant	36.19	30.38	S
1937	Unthinned	6" apart	24.15	23.31	NS
1938 a	Unthinned	10" apart	33.98	33.10	NS
1938 b	Unthinned	10" apart	37.84	36.15	NS
Woodman et al. 1936	Unthinned	9-30" aver. 18" apart	13.8 to 15.7	10 to 12.6	Not given
Morrison and Hale					
1936	6" apart	12" apart	27.2	24.3	S
1937	6" apart	12" apart	18.3	14.7	S
Fagan et al. 1945	Unthinned	6" apart	22.05	24.70	Not given
N.I.R.D. Ann.Rep.					
1946	2" apart	9" apart	25.08	25.79	NS
1946	2" apart	18" apart	25.08	22.53	S
1946	9" apart	18" apart	25.79	22.53	S

[1] The green matter yields are means of yields obtained from thinning treatments at several levels of nitrogen manuring except those from the Rothamsted Annual Report (1932a) which are means obtained from a thinning treatment at two levels of cultivation intensity.

[2] S = significant NS = non-significant

Reference to Table I brought several salient points to light. In the majority of the trials, unthinned marrow-stem kale gave greater green matter yields than thinned. Though, on the basis of these tabulated results, it would appear that thinning did not cause a marked depression in yield where the spacing interval between plants was twelve inches or less. Appraisal of those results subjected to statistical analysis showed yield differences to be frequently significant where the spacing interval in thinned marrow-stem kale was twelve inches or more. In particular, the eighteen-inch thinning treatment appeared to cause significant yield reduction in comparison with the unthinned treatment. The results from the Rothamsted Annual Report (1936) should be interpreted with caution, as the thinning treatment was not uniformly applied and was therefore not capable of future repetition.

In New Zealand, Robinson (1956) conducted trials on the effect of seed rate and row spacing on marrow-stem kale growth. The yields obtained from different seed rates did not differ significantly and this was in accordance with previous years' work. Though the closely spaced rows outyielded the widely spaced rows on this occasion, previous work had shown the value of the latter where weed competition was severe; weed control by inter-row cultivation had been at least partly effective in increasing yields.

It can thus be readily seen that the effect of thinning on the yield of marrow-stem kale has been by no means consistent in the past. Indeed, on this subject, Sanders (1949) has stated:

"Experiments comparing thinned and unthinned kale contradict each other so diametrically that it can only be concluded that there is little difference in yield."

In addition to total yield, the importance of the relative proportions of leaf and stem components in marrow-stem kale is recognized in the literature; several authors have recorded data on this aspect. In the Rothamsted Annual Reports (1932, 1933), it was reported that the ratio of leaf to stem was significantly greater in thinned than unthinned plots, both on a green and dry matter basis. Further, as the crop matured, the ratio of leaf to stem decreased; this was partly due to continued development of the stem component and partly to shedding of the lower leaves.

Similar results were obtained from investigations at two different centres in Sweden by Edin et al. (1933), who found that the percentage of leaf in marrow-stem kale decreased from 73 to 37% and from 63 to 49% (green matter basis) at the respective centres, over a period of only four weeks. It was further found that the leaf percentage tended to be higher in thinned than in unthinned crops. A decrease in leaf to stem ratio with advancing season was also reported in the Rothamsted Annual Report (1932), by Bünger et al. (1933) and Robinson (1954).

Simola (1932), a Finnish worker conducted a series of experiments dealing with the effect of thinning on marrow-stem kale growth. Leaf percentages (dry matter basis) of 53, 52, 58, 60 and 60 were obtained for unthinned, 4, 8, 12 and 16-inch thinned crops respectively. He commented that larger differences between the well-thinned and less-thinned stands might have

resulted but for a period of severe drought.

Fagan et al.(1943), who studied the effect of thinning on the composition of marrow-stem kale, also noted that a higher leaf percentage was evident in thinned than in unthinned crops.

In New Zealand, Robinson (1957) compared the effect of different row spacings and different seed rates on the leaf percentages of marrow-stem kale. The results indicated that row spacings did not affect the leaf percentages whilst the results from several trials on different seed rates were inconsistent and no conclusion could be drawn.

The leaf to stem ratio was also influenced by the type of marrow-stem kale and in New Zealand, two types have been marketed commercially through the certification scheme of the Department of Agriculture. These two types, "Government certified" giant and medium-stemmed marrow-stem kale respectively, were the result of selection by Calder (1939, 1944). He found that although the giant marrow-stem kale had a lower ratio of leaf to stem than the medium-stemmed marrow-stem kale, the total-leaf yields of the two types did not differ greatly because the giant type had a higher total crop yield. Robinson (1950, 1952) also reported that medium-stemmed marrow-stem kale produced a higher leaf to stem ratio than giant marrow-stem kale.

At Reading, England, trial plots of an English commercial marrow-stem kale were compared with plots of the above two certified New Zealand types; the New Zealand medium-stemmed type produced a higher leaf yield per acre than either of the other two (N.I.R.D.[1] report, 1946).

[1]National Institute for Research in Dairying

(b) Composition

Chemical analysis may be regarded as the starting-point in assessing the nutritive value of animal feeding-stuffs. By convention, a feeding-stuff is generally analysed for crude protein, crude fibre, ether extract, mineral matter and nitrogen-free extract. In the following review, the dry matter percentage of marrow-stem kale is discussed first and then each of the above respective feed constituents in turn; discussion of the latter is on a dry matter basis. Experimental data on the composition of marrow-stem kale have been summarized in Table II.

Dry Matter Percentage

Reference to Table II showed that Edin et al. (1933) quoted dry matter percentages for marrow-stem kale varying from 12.5 to 14.8. These figures were calculated from investigations in Sweden, Finland and Denmark. Kivimäe (1950), on the basis of a number of trials over four years, found dry matter percentages ranging from 13.1 to 16.4, overall average 14.5. It was suggested that the variation from year to year was caused partly by climatic factors (temperature and precipitation), partly by the type of marrow-stem kale and partly by the density of plants per acre. This investigator further concluded, from a series of weekly samples each year during the normal utilization period, that the dry matter percentage during the season did not change systematically.

Axelsson (1949) distinguished between leafy and stemmy types of marrow-stem kale and gave respective average percentages of 13.8 and 14.3.

Table II

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Table II

Summary of Data in the Literature for the Percentage Composition of Unthinned and Thinned Marrow-stem Kale, and Component Parts of Marrow-stem Kale (dry matter basis)

Authority and Country	Description of Marrow-stem Kale	Sampling Date	Percentage Composition[1] DM	CP	CF	EE	NFE	MM
Edin et al. (1933) Sweden	Unthinned	End Sept.	13.8	14.5	21.4	3.5	60.6	17.9
	Unthinned	Mid. Dec.	14.6	14.1	17.3	4.0	64.6	15.4
	Unthinned	End Oct.	14.6	15.5	16.6	3.7	64.2	18.9
	Unthinned	Beg. Nov.	14.8	14.8	16.0	3.7	65.5	16.1
(Aver. Finnish Trials, a)	Thinned		14.1	14.0	14.6	3.8	67.6	10.5
(Aver. 30 Fin. Trials, b)	-		14.5	14.8	16.5	3.3	65.4	13.6
(Aver. Danish Trials)	-		12.5	22.3	23.0	3.1	51.6	17.6
Bünger et al. (1933) Germany	-		13.1	18.4	17.0	2.3	47.3	15.1
Woodman et al. (1936) U.K.	Unthinned	Oct.	13.3	16.2	18.3	4.0	46.4	15.2
	Thinned	Oct.	13.5	13.2	18.6	2.5	52.2	13.5
	Unthinned	Jan.	14.2	14.6	18.3	2.8	52.7	11.5
	Thinned	Feb.	14.2	16.0	17.9	2.3	51.2	12.6
Watson and Horton (1936) U.K.	Mature		15.9	9.9	14.9	2.2	61.4	15.9
	Mature		14.4	11.4	16.7	2.0	57.8	14.4
	Mature		14.0	11.3	16.5	2.0	58.3	14.0
	Mature		13.6	12.3	16.7	2.0	57.1	13.6
	Immature		12.8	22.1	11.5	3.5	47.2	12.8
Kirsch and Jantzon (1935) Germany	Mature		15.1	8.1	20.1	1.6	60.4	-
	Mature		11.1	15.1	19.5	3.4	49.4	-
Schmidt and Schleinitz (1933) Germany	Dan.var. a	Sept.	9.8	19.8	22.4	5.2	37.1	15.5
	Dan.var. b	Sept.	9.0	17.4	21.2	4.8	41.2	15.5
	Eng.var. a	Sept.	9.8	18.1	19.5	5.5	42.9	14.0
	Eng.var. b	Sept.	9.5	17.4	22.5	4.5	41.1	14.5
	Dan.var. a	Oct.	9.4	19.2	18.8	2.4	46.2	13.4
	Eng.var. a	Nov.	12.2	19.3	16.2	2.1	49.9	12.6
Fagan et al. (1943) U.K.	Unthinned	Oct.	12.7	10.7	23.4	3.5	50.6	11.8
	Thinned	Oct.	9.0	17.9	16.1	5.0	45.5	15.5
	Unthinned	Nov.	16.5	8.2	21.3	2.4	60.6	7.6
	Thinned	Nov.	11.3	16.3	18.1	3.7	49.9	12.1
Fagan et al. (1945)	Unthinned	Aver. over season	13.2	19.6	20.8	3.6	46.1	9.9
	Thinned		12.6	20.0	21.6	3.9	43.2	11.4
Axelsson (1949) Sweden	Leafy		13.8	15.9	16.7	2.2	52.2	13.0
	Stemmy		14.3	13.3	18.9	2.1	53.8	11.9
Kivimäe[93] (1950) Sweden		1945	16.4	10.6	17.1	2.3	50.9	11.1
		1946	13.1	12.7	15.1	2.6	56.3	13.3
		1948	14.5	11.4	17.6	2.1	58.1	10.8
		1949	14.2	10.4	20.6	2.3	54.5	11.9
		4 yr. av.	14.5	11.3	17.7	2.3	56.9	11.8
(Average for four years)		Oct. 1	13.9	12.7	16.9	2.6	54.7	13.1
		8	13.8	11.5	16.9	2.3	56.6	12.5
		15	15.1	10.9	18.2	2.3	56.3	12.3
		22	15.6	10.4	16.7	2.2	59.4	11.3
		29	13.9	11.0	17.7	2.2	58.0	11.1
		Nov. 5	14.9	10.9	18.2	2.2	57.8	10.9
		12	14.6	11.4	18.4	2.1	57.4	10.7
Woodman et al. (1936) U.K.	Thinned: Leaf	Oct.	12.2	13.9	12.5	3.3	55.5	14.9
	Marrow	"	8.6	12.0	13.1	1.3	50.4	15.2
	Rind	"	16.5	7.7	29.1	0.8	55.3	7.1
Fagan et al. (1943) U.K.	Unth. leaf	Nov.	14.7	13.6	23.6	3.7	47.4	11.8
	Thin. leaf	"	15.0	12.7	19.2	3.7	55.0	9.4
	Unth. stem	"	19.0	6.9	25.1	1.3	38.9	8.6
	Thin. stem	"	12.7	7.3	20.5	1.9	61.6	5.7
	Thinned: lamina	Dec.	16.0	12.8	17.7	4.6	38.3	9.8
	petiole	"	12.8	6.2	22.3	1.9	60.5	6.7
	marrow	"	9.8	13.0	16.5	0.8	57.6	12.2
	rind	"	15.6	9.2	33.7	0.5	40.8	7.9

[1] DM = Dry Matter; CP = Crude Protein; CF = Crude Fibre; EE = Ether Extract; NFE = Nitrogen-free Extract; MM = Mineral Matter

Fairly good agreement with the aforementioned results was furnished in German investigations by Bünger et al. (1933, 1935), Kirsch and Jantzon (1935) and Schmidt et al. (1933); the latter further noted distinctly higher percentages during November than September. On the other hand, Wöhlbier (1932) found great variation in dry matter content and obtained values as wide apart as 7.3% and 17.5%. Values ranging from 11.5 to 16.7% in Norwegian trials were reported by Krosby and Ulvesli (1953).

From dry matter determinations of thinned and unthinned marrow-stem kale, Woodman et al. (1936) concluded that thinning exercised little effect on dry matter content; the figures did reveal increasing dry matter percentages with advancing season though. Plant component-part dry matter percentages were in the descending order of stem rind (rind being tissue exterior to the stem marrow), total stem, leaf and stem marrow respectively. A tendency of increasing dry matter percentages with advancing season was also indicated by Schmidt and Schleinitz (1933), Watson and Horton (1936) and Fagan et al. (1943). From the Rothamsted Annual Report (1932), monthly analyses from November to March showed the stem to be higher in dry matter content than the leaf, except during the latter half of the sampling period, when the position was reversed.

Contrary to the findings of Woodman and his co-workers, Miller (1933), Morrison and Hale (1936) and the N.I.R.D. report (1946) claimed that thinning caused a decrease in the dry matter percentage of marrow-stem kale. The latter report further stated that thinning did not affect the dry matter content of the leaves, but reduced that of the stem. It was also noted that

nitrogen fertilization slightly reduced the dry matter percentages of leaves and stems. Fagan et al. (1943) obtained values for unthinned marrow-stem kale in the region of 3 to 5% more than for thinned; on another occasion though, (Fagan et al., 1945), they found the difference between thinned and unthinned to be less than 1%. Separation into plant component parts gave dry matter percentages in the descending order of leaf lamina, stem rind, leaf petiole and stem marrow respectively. From a series of trials in New Zealand, Robinson (1957) found that the leaf component of marrow-stem kale was invariably higher in dry matter content than the stem component. Figures from different Swedish centres quoted by Edin et al. (1933) showed similar results. They also noted however, that Simola in Finland found, on the contrary, that the dry matter content was higher in the stems than the leaves.

Crude Protein Percentage

According to the data collated by Edin et al.(1933), crude protein percentages of marrow-stem kale varied within narrow limits, 11.9 to 12.8, except the average value for Danish analyses, which was quoted as 18.4%. In explanation of the latter, it was suggested that climate, growth period, varietal characteristics and method of cultivation were among the factors which could have caused this. If the crop was indeed a leafy type, or at an early stage of growth, the crude fibre percentage of 23.0 would appear to be surprisingly high. However, Schmidt and Schleinitz (1933) also obtained high values for both crude protein and crude fibre from crops sampled early in the season.

From a series of trials, Kivimäe (1950) obtained an average value of 11.3% crude protein. Over a six-week sampling period from October to November, weekly figures averaged for four years showed that the content of crude protein was highest at the beginning of October, and decreased slightly to an approximately constant figure during the latter part of the season. Decreasing crude protein percentage with advancing season was also noted by Fagan et al.(1943) for thinned and unthinned marrow-stem kale and by Schmidt and Schleinitz (1933). It was suggested in the literature that the decline in crude protein percentage with season was chiefly the result of shedding of the protein-rich leaves as the plant matured. Crude protein values fairly similar to those already mentioned were listed by Watson and Horton (1936) and Krosby and Ulvesli (1953). Axelsson (1949) quoted figures of 15.9 and 13.3% crude protein for leafy and stemmy marrow-stem kale types respectively.

Woodman et al. (1936)who investigated the composition of thinned and unthinned marrow-stem kale in detail, did not drew conclusive results as to whether or not thinning influenced the crude protein percentage of the plant. Their results did indicate that the leaf component was highest in crude protein, the stem rind lowest and the stem marrow only slightly lower than the leaf. This was further verified by Fagan et al. (1943), who also found that the leaf lamina had a markedly higher value than the leaf petiole. That the leaf component was superior in crude protein percentage to the stem component was similarly indicated by Bünger et al. (1933, 1935), Edin et al. (1933), Watson and Horton (1936), the Rothamsted Annual Report (1932) and the N.I.R.D.

Report (1946).

The effect of thinning and nitrogen fertilization on crude protein percentage was also noted in the latter report. In marrow-stem kale which did not receive nitrogen, the average percentages of crude protein in the leaf dry matter were 18.3, 17.3 and 17.3 for the 2, 9 and 18-inch spacing respectively, whilst for the crop which did receive nitrogen, the corresponding percentages were 21.6, 22.1 and 21.4. Likewise, in the dry matter of the stems, the average percentages were; without nitrogen, 5.2, 6.9 and 6.9; with nitrogen, 7.3, 10.9 and 11.8. Thus thinning was efficacious in raising the crude protein percentage of the crop by having greatest effect on the composition of the stem component. Simola (1932) found thinning to cause an increase in crude protein percentage of both leaves and stem. Further results indicating that thinned marrow-stem kale was markedly superior in crude protein content to unthinned were presented by Miller (1933), Morrison and Hale (1936, 1937), Fagan et al.(1943, 1945) and Krosby and Ulvesli (1953).

Crude Fibre Percentage

Crude fibre percentages from 13.1 to 19.0 were quoted by Edin et al.(1933); there did not appear to be much change in crude fibre percentages with advancing season, as evidenced from values obtained at different times during the year. Woodman et al.(1936) found no great difference in the crude fibre percentages of thinned and unthinned marrow-stem kale. Neither was there any percentage increase as the season advanced, the values varying within narrow limits, for both unthinned and thinned marrow-stem

kale, of 17.9 to 18.6%. The most fibrous part of the plant was the stem rind, followed by the stem marrow, which in turn was only slightly greater than the leaf. The Rothamsted Annual Report (1932) and Wöhlbier and Schramm (1934) also noted that the leaf component was lower in crude fibre percentage than the stem component. Fagan et al.(1943) found the crude fibre percentages of the plant component parts to be in the descending order of stem rind, leaf petiole, leaf lamina and stem marrow respectively. Contrary to Woodman and his co-workers, Fagan and his co-workers further found that unthinned marrow-stem kale had a distinctly higher percentage of crude fibre than thinned. As separate analyses showed, this was the case in both leaf and stem components; no marked percentage change with advancing season was noted.

Miller (1933), Krosby and Ulvesli (1953) and Simola (1932) have also noted that thinned marrow-stem kale was lower in crude fibre percentage than unthinned. The latter author noted this to be the case for both leaf and stem components. In two successive years, Morrison and Hale (1936, 1937) reported very little difference in crude fibre percentages of thinned and unthinned marrow-stem kale. Unthinned plants had slightly higher percentages the first year though.

Contrary to some of the aforementioned results showing little change in crude fibre percentage with advancing season, data, collected by Kivimäe (1950) over four years, indicated that the percentage rose slightly from beginning to end of the season; the range of variation was 16.9 to 18.4%.

The difference between leafy and stemmy types of marrow-stem kale was shown by Axelsson (1949), who presented crude fibre percentages of 16.7 and 18.9 for these respective types. Watson and Horton (1936) gave a percentage of 11.5 for a crop at an early, leafy stage of growth whilst for mature crops, the values ranged from 14.9 to 14.7%.

Ether Extract Percentage

Only a very small proportion of the percentage composition is represented by ether extract in marrow-stem kale, usually less than 5%. Values quoted by Edin et al.(1933) varied within very narrow limits, 2.6 to 3.4%, whilst those given by Kivimäe (1950) ranged between 2.1 and 2.6%. In the latter's investigations, as in those of Edin et al. and Schmidt and Schleinitz (1933), the ether extract percentage showed a tendency to decrease from the beginning to the end of the season. This tendency was also noted by Woodman et al.(1936) and Fagan et al. (1943). The former, in addition, found that unthinned marrow-stem kale had a higher percentage of ether extract than thinned. Analyses of the plant component parts showed the leaves to be highest in ether extract percentage, followed by the stem marrow and finally the stem rind. That the leaf component was superior to the stem component was also borne out in trials conducted by Fagan and his co-workers; further fractionation of these components by the latter workers showed that percentages were in the descending order of leaf lamina, leaf petiole, stem marrow and stem rind respectively. In accordance with this, Axelsson (1949) found leafy forms of marrow-stem kale to be higher in ether

extract percentage than stemmy types. Similar results were obtained by Watson and Horton (1936) in a comparison between leafy immature and mature crops.

Mineral Matter Percentage

An outstanding feature of the marrow-stem kale crop was its value as a source of mineral matter. Edin et al.(1933) recorded figures ranging from 10.5 to 18.9% in their table of results from different European centres. The variation in values quoted by Kivimäe (1950) was less than the above and was within limits of 10.8 to 13.3%, with an overall average of 11.8%, for a number of trials over four years. He also noted, as did Edin and his co-workers, a tendency for the mineral matter percentage to decrease from beginning to end of the season.

In their comprehensive investigations with marrow-stem kale, Woodman et al.(1936) recorded values ranging from 11.5 to 15% and further noted that the values tended to decrease with advancing season. No conclusive results were drawn on the effect of thinning the crop. Analyses of the component parts revealed the stem marrow to be highest in mineral matter percentage, closely followed by the leaf and finally the stem rind. The constituent elements of the mineral matter were also presented and the notable feature of these results was the high percentage of calcium and potassium in the crop. Chlorine, sulphur and phosphoric acid were also fairly well represented.

Investigation of the distribution of minerals in the marrow-stem kale showed the leaves to be richest in calcium and sulphur, whilst the stem marrow was richest in phosphoric acid,

potassium and magnesium. The stem rind, though poor in mineral matter relative to the leaf and stem marrow, nevertheless made a useful contribution to the mineral matter content of the plant as a whole.

Fagan et al.(1943, 1945) observed that thinned marrow-stem kale had a higher mineral matter percentage than unthinned; the tendency of decreasing percentages with advancing season was marked in both the thinned and unthinned crop. Values for calcium and phosphoric acid were similar to those given by Woodman and his co-workers and by Watson and Horton (1936). The results further showed that leaf was the main source of calcium and stem the main source of phosphoric acid. The superiority of the leaf component over the stem component as a source of minerals was also noted by Bünger et al.(1933), Edin et al.(1933) and Withycombe and Bradley (1908).

Axelsson (1949), who distinguished between leafy and stemmy types of marrow-stem kale, found the former to be slightly higher in mineral matter percentage. The effect of leafiness was further demonstrated by results given by Watson and Horton (1936); they found percentages of 15.8 and 11.6 to 12.0 for leafy immature and mature crops respectively.

Nitrogen-free Extract Percentage

Reference to the values quoted by Edin et al.(1933) indicated marrow-stem kale nitrogen-free extract percentages ranging from 42.5 to 60.5. Of all the "conventional" feeding-stuff constituents nitrogen-free extract showed the greatest variation.

Kivimäe (1950), who obtained an average of 56.9% for

nitrogen-free extract, found it to be at its highest level in the middle of the season. Woodman et al.(1936), in their analyses, could not distinguish any marked trend in nitrogen-free extract percentage during the season, nor did they find much variation between thinned and unthinned marrow-stem kale. They did show that over 50% of the marrow of the plant was total sugar though. Examination of the component parts proved stem marrow to contain the highest percentage, followed by leaf and stem rind in that respective order. Fagan et al.(1943, 1945) obtained values indicating that unthinned marrow stem kale was higher in nitrogen-free extract than thinned, whilst the superiority of stem over leaf was also marked. Component-part percentages were in the descending order of leaf petiole, stem marrow, leaf lamina and stem rind respectively. Bünger et al.(1933) also stated that the stem component was richer in nitrogen-free extract than the leaf component.

Axelsson (1949) found very little difference between the nitrogen-free extract contents of leafy and stemmy types of marrow-stem kale, though the latter was just slightly higher. The early leafy crops of marrow-stem kale analysed by Watson and Horton (1936) also gave a lower value, 47.2%, than more mature stemmy crops, which ranged from 57.1 to 61.4%.

Carotene

Only one reference, that of Kivimäe (1950), was found dealing with the carotene content of marrow-stem kale. For several analyses in each of four years, he obtained average carotene contents of 71, 121, 60 and 69 µg per gram dry matter

respectively. He also obtained weekly contents over a six-week period from 1st October to 12th November inclusive, in each of these years. The weekly carotene contents averaged for the four years, were 105, 103, 85, 72, 78, 67 and 60 µg per gram dry matter respectively. The carotene content therefore decreased continually from the beginning to the end of the sampling period.

(c) Palatability and Digestibility

Palatability

Much literature has been written about the palatability of food for animals. Probably the most notable feature in the writings has been the controversy which surrounds its definition. No one definition has been universally accepted as yet.

In the literature perused, no critical experimentation dealing with the palatability of marrow-stem kale could be traced. Conceivably, the value of palatability with marrow-stem kale, as with food for animals generally, lies in the extent to which it influences food intake. The importance of the latter has probably been best summed up by Brody (1945), who stated that:

"Normally the greater the food consumption, the greater the speed and economy of the production process (growth, milk production, egg production and so on), because of the reduced overhead maintenance cost per unit food consumption."

Digestibility

In evaluating the nutritive value of food for animals, it has already been noted that the starting-point is chemical analysis. It is then required to know how much of each individual constituent is digestible and therefore utilizable by the animal. This is accomplished by digestibility trials and these have formed the basis of many investigations in animal nutrition.

Data on the digestibility of marrow-stem kale from a series of trials are presented in Table III. In his publication on the digestibility of the feeds of the world, Schneider (1947) listed a total of fourteen references, ten of which were by

Table III

Table III

Summary of Data in the Literature for Apparent Digestion Coefficients of Marrow-stem Kale Chemical Constituents

(determined in trials with sheep, unless otherwise stated)

Description of Marrow-stem Kale	Authority	Comments	Digestion Coefficients[1]				
			OM	CP	CF	EE	NFE
Danish	Schmidt and Schleinitz (1933)	German trials	76.0	85.4	49.8	88.1	82.0
Var.[2]			80.8	85.8	55.6	95.2	86.4
Eng.Var.[2]							
Mature	Bünger et al. (1933)	German trials	80.7	83.5	55.9	64.5	89.3
Immature	Richter and Ferber(1933)	German trials	85.7	82.3	65.3	-	95.6
Mature			69.3	79.6	40.5	-	79.0
Leaves[2]	Wöhlbier and Schramm(1934)	German trials	87	83	90	47	90
Stems[2]			78	80	51	69	88
Fresh a	Kirsch and Jantzon(1935)	German trials (1932)	83.6	73.7	64.6	34.2	92.6
Dried		(1932)	80.8	72.1	59.7	56.8	90.2
Fresh b		(1933)	87.5	85.0	80.2	55.8	93.1
Unthinned a	Edin et al. (1933)	Swedish trials End Sept.	75	73	47	68	85
Unthinned a		Mid.Dec.	80	72	57	67	88
Unthinned b		End Oct.	79	78	45	65	89
Unthinned b		Beg.Nov.	76	78	35	64	86
Thinned		Finnish trial	87	75	75	73	93
Fed dry[3]	Edin and Sunderlin (1930)	Swedish trial	68	68	53	25	77
Unthinned	Krosby and Ulvesli(1953)	Norwegian trial	76	75	52	-	-
Thinned			79	81	57	-	-
Unthinned	Woodman et al. (1936)	British trials Sept.	80.8	81.6	66.6	59.8	88.0
Unthinned[2]		Jan.	80.1	76.3	61.9	64.9	88.3
Thinned [2]		Oct.	80.8	78.1	62.0	51.3	89.5
Thinned [2]		Jan.	78.3	78.8	54.2	47.9	88.0
Mature	Watson and Horton(1936)	British trials	85.7	69.3	82.5	71.4	89.2
Mature			82.3	68.1	74.6	65.9	87.5
Mature			80.8	67.9	71.9	71.4	86.9
Mature			82.1	68.8	75.5	65.8	88.2
Immature			85.2	88.4	78.8	69.1	86.9
Mature	Watson (1939)	British trial	85.0	88.0	74.3	68.4	87.4
Mature	Watson (1940)	British trial	82.7	68.5	76.1	68.6	87.9
	Schneider (1947)	Review Publn. No. of trials:					
Fed dry		1	81	72	60	57	90
Fed dry[3]		1	68	68	53	25	77
Fed green:							
Mature		28	82	82	69	58	88
Mature[2]		9	82	74	70	62	89
Mature[3]		4	78	75	48	66	88
Immature		4	81	80	64	56	89
Immature[2]		4	79	78	58	58	88
Pre-bloom		2	85	88	74	68	87
Leaves[2]		1	87	83	90	47	90
Stems[2]		3	78	80	51	69	88

[1]Abbreviations as in Table II.
OM = Organic Matter

[2]Digestibility determined by "difference" method.

[3]Digestibility determined using cattle.

German authors, for digestibility trials conducted with marrow-stem kale.

Kirsch and Jantzon (1935) and Edin and Sunderlin (1930), using sheep and steers respectively as experimental animals, determined the apparent digestion coefficients of the conventional constituents of marrow-stem kale fed dry. The values obtained did not differ greatly from those quoted by other workers, who fed fresh marrow-stem kale.

The digestion coefficients quoted by Schneider (1947) for the constituents of immature and pre-bloom marrow-stem kale tended to be higher, though not consistently so, than those quoted for the constituents of mature marrow-stem kale. This was in agreement with the results obtained by Watson and Horton (1936) and Edin et al.(1933).

Woodman et al.(1936), who obtained the digestion coefficients of thinned and unthinned marrow-stem kale, found little difference between them, except in the case of the crude fibre and ether extract constituents. In these, the coefficients were several per cent less in thinned than unthinned marrow-stem kale. This was not in accordance with Edin et al.(1933), who quoted figures showing that thinned marrow-stem kale constituents had higher digestion coefficients than unthinned marrow-stem kale constituents. The values recorded by Krosby and Ulvesli (1953) also indicated that thinning had raised the digestion coefficients of marrow-stem kale constituents.

The digestion coefficients of marrow-stem kale leaves and stems respectively were determined by Wöhlbier and Schramm (1934). Higher coefficients were obtained from the leaves

than from the stems, particularly for the crude fibre constituent. Least difference in the coefficients of the two parts of the plant was found in the crude protein and nitrogen-free extract constituents.

E X P E R I M E N T A L

C H A P T E R III

YIELD

This section will be presented in four parts as follows:

(a) The planning, layout and establishment of the experimental area.

(b) The experimental procedure employed with yield measurements.

(c) The experimental results obtained from the trial.

(d) Discussion of the experimental results.

(a) Planning, Layout and Establishment

Experimental Area

The site chosen for the experiment was in paddock No.8 of the Production-per-Acre trial dairy farm of Massey Agricultural College. This trial project was outlined by Riddet (1954). The paddock was sown to pasture in the autumn of 1948, following a crop of marrow-stem kale. The history for the five years prior to ploughing was:

1952 Hay and pasture.

1953 Pasture.

1954 Pasture; oversown with grass (March).

1955 Pasture; oversown with millet (January)and grass (May).

1956 Hay and pasture; oversown with barley, grass and turnips (February).

Superphosphate, at the rates of 3, 0, 6, 2 and 3 cwt. per acre for the years in order as above respectively, was applied.

The soil, formed from a river alluvium, was classified as a "Recent Soil" in the New Zealand Soil Bureau Bulletin No.5 (1954). The profile characteristics, detailed by Pollok (1957) were:

0-8" Brown silt loam.

8-10" Dark blue-grey silt loam, anaerobic pugged layer.

10-12" Yellow-brown silt loam.

12-20" Yellow-brown fine sandy loam.

20-36"+ Fine to medium sand.

The paddock (4 acres) was used to over-winter the Jersey herd of 33 cows plus replacements in 1956 and from late summer

to the end of the winter, forage crops, hay and silage were fed out; by spring, little herbage was visible and the soil surface was severely pugged (fig.1). The paddock was ploughed at the end of August and disced twice. It was then levelled, disced lightly and finally rolled with a Cambridge roller.

The part chosen for the experiment was an area of 56 yards by 51 yards in the south-western portion of the paddock. The area was fairly level and though sheltered from wind by hedges, which enclosed the paddock on all sides, was still open to the sun.

Planning and Layout

In planning the layout, two factors were taken into account; firstly, suitability for statistical examination of the results and secondly, sufficient area to provide sampling material for yield and composition determinations, sufficient feed for digestibility trials using sheep and sufficient "guard" material to prevent border effects.

A randomized block design was chosen (Snedecor, 1956, pp.291 et sqq). Within each of a total of four blocks, the three treatments, namely, not thinning, 6" thinning and 12" thinning, were allocated at random. The treatments were therefore replicated four times. Each plot, measuring 7 yards by 28 yards, was demarcated with wooden pegs. Around the perimeter of the experimental area, 3-foot discards were left to facilitate the removal of samples from the crop. A 3-foot discard was also allowed for between Blocks I, II and III, IV. The final layout is shown in figure 2.

Figure 1

Pugged Soil Surface in Paddock No.8,
August, 1956

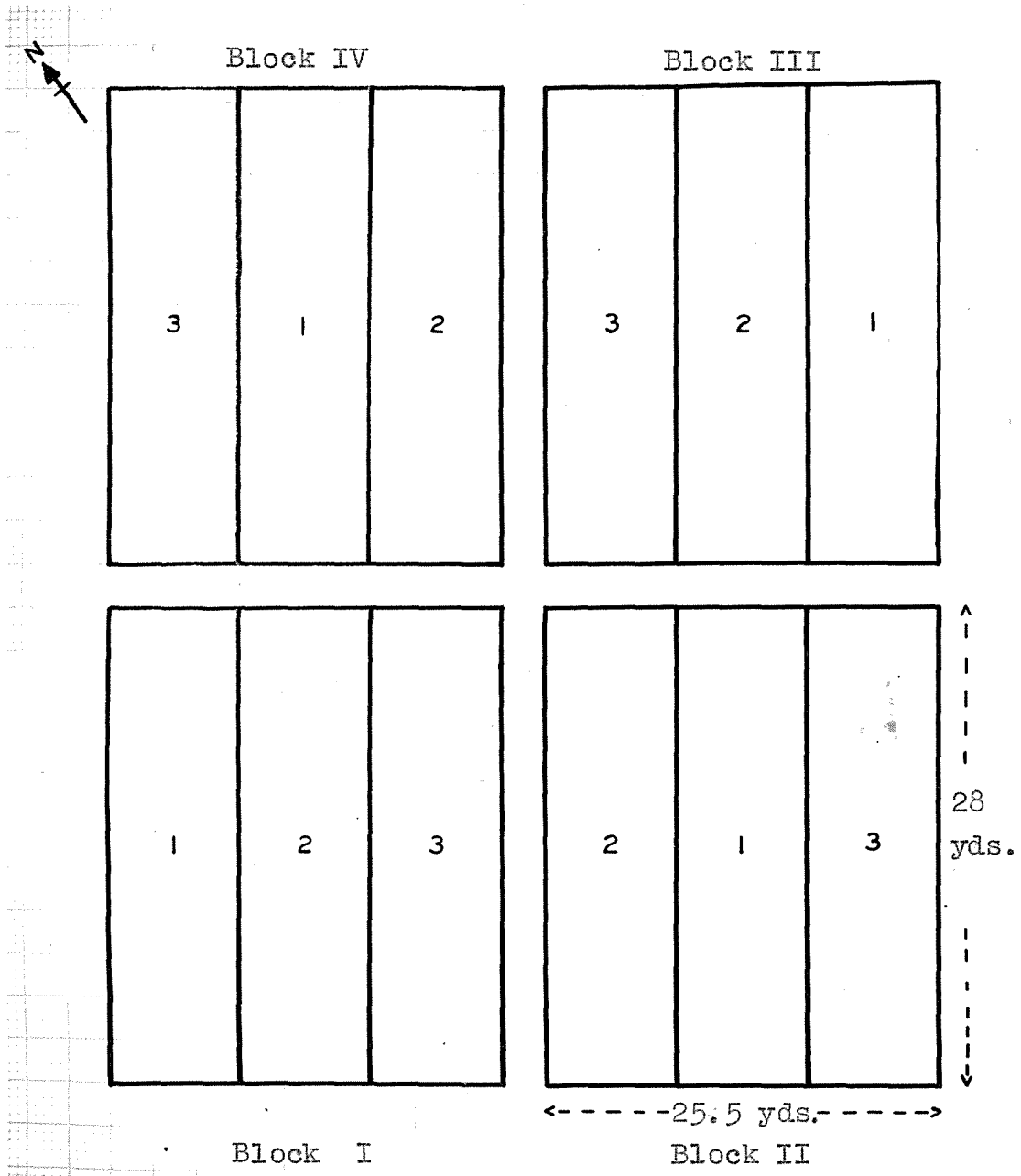


Figure 2

Experimental Layout

Within the plots, marrow-stem kale rows were spaced 21 inches apart and each plot had a total of thirteen rows. Five of these were guard rows; the two outer rows and one row between each of four adjacent pairs of sample rows. Along the sample rows, 6-foot lengths, reserved for yield determinations, were alternated with 6-foot guard lengths, except at the end of rows, where the guard lengths were 9 feet. There was thus a total of twenty-four 12-foot sample lengths (in paired 6-foot lengths) in each plot. Further 3-foot lengths from the middle of the above sample row guard lengths and from corresponding positions in the guard rows, were reserved to supply feed for the sheep employed in the palatability and digestibility trials and to provide samples for carotene estimations. A plan of these details with one plot as an example, is shown in figure 3.

The seed, obtained from the New Zealand Department of Agriculture, was Mother Marrow-stem Kale Seed, Certified Giant Type.

Establishment and Routine Care

After the final cultivation of rolling, superphosphate, at a rate equivalent to 3 cwt. per acre, was drilled into the experimental area using a seed and fertilizer drill with the coulters spaced 21 inches apart. No further fertilizer was applied at any time during the course of the experiment.

On September 21st 1956, the seed was sown on the flat using a modified Planet Junior hand seed-drill (fig.4). This drill was designed for small plot work. The shallow furrow left by the coulter tip when drilling fertilizer was used as a guide line to follow with the seed-drill. Due to stirring of the soil

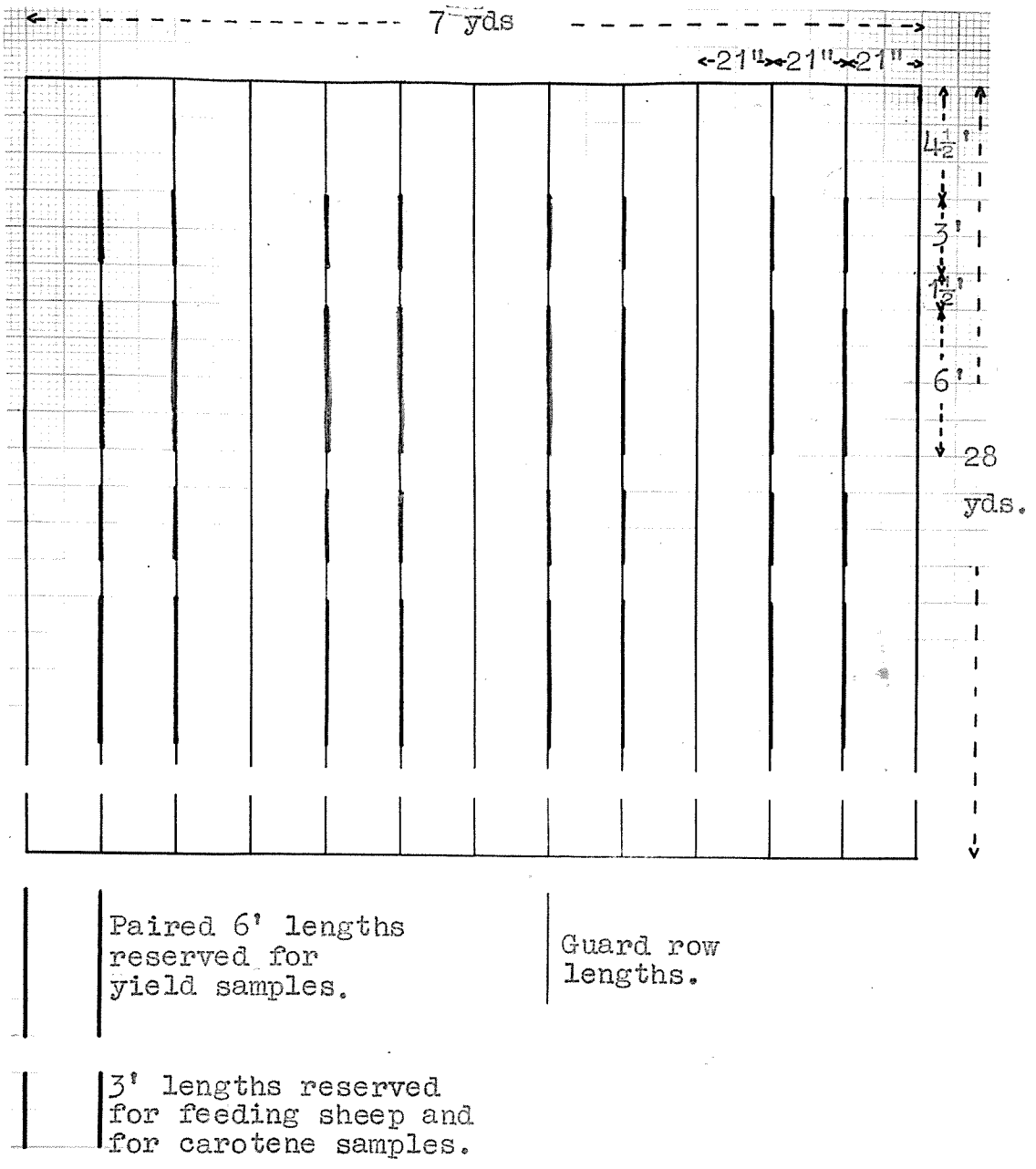


Figure 3

Experimental Plot

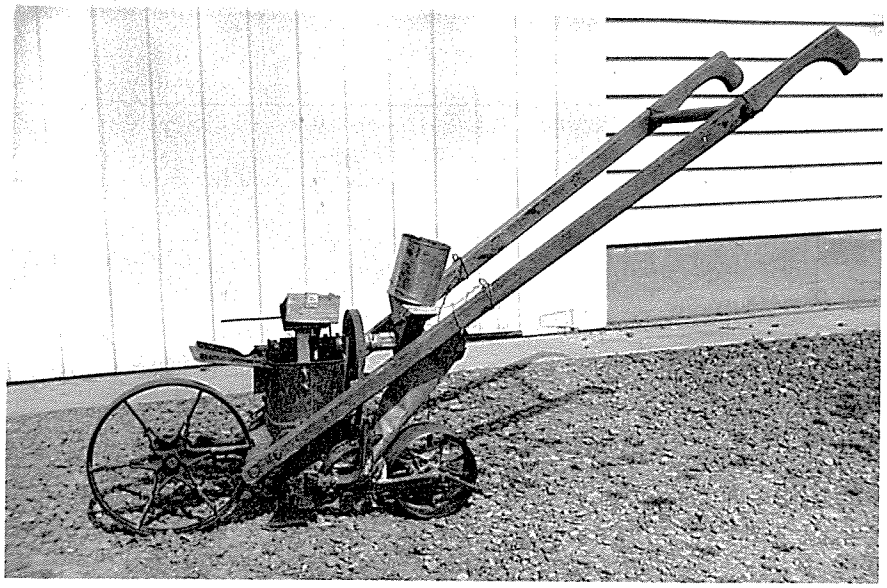


Figure 4

Modified Planet Junior Hand Seed-drill
(fertilizer attachment since added)

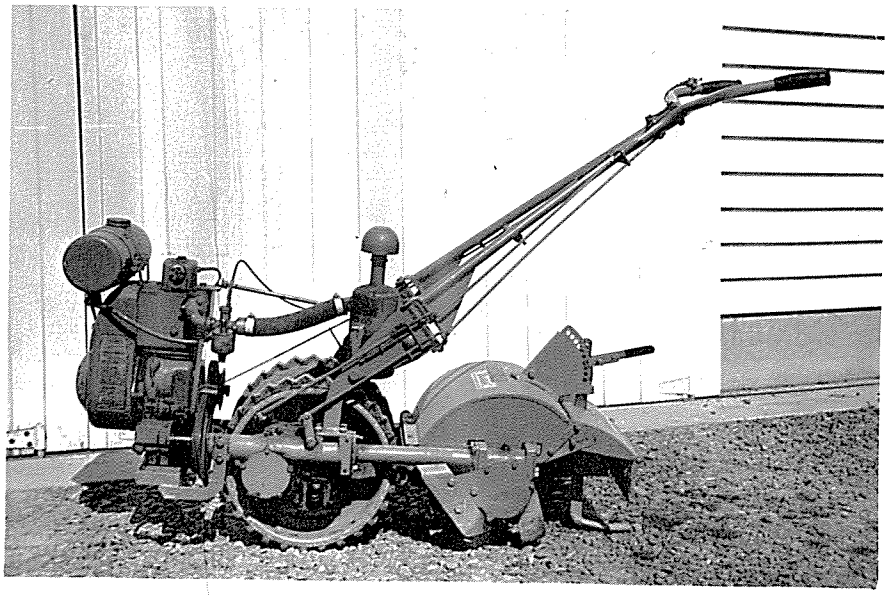


Figure 5

Hand-operated Rotary Cultivator

by the fertilizer drill coulters, the soil surface was rather loose and the seed-drill roller was not heavy enough to effect consolidation. A weighted wheelbarrow with a broad rubber tyre was therefore used to consolidate the soil along the fertilizer row before drilling the seed. Seed rates equivalent to 3 lb. and 1½ lb. per acre were used on the plots to be left unthinned and thinned (6" and 12") respectively. Establishment was poor, probably due to a combination of very dry weather and insufficient consolidation. Plant counts showed adequate numbers in the plots which were to be thinned, but it was felt that the density of plants in the plots which were to be left unthinned was not sufficient to offer a good contrast to the thinned plots. Consequently a second sowing was carried out on October 6th with seed rates equivalent to 2 lb. and 1 lb. per acre on the plots to be left unthinned and thinned respectively. By sowing all plots at rates proportional to the previous rates, each plot had a similar proportion of plants from the second sowing. A bias in treatment differences due to age was therefore prevented. Establishment following this was good and plant growth soon appeared to be fairly uniform.

Thinning was effected by means of a push hoe; at first, a wooden pole, six feet long, marked in feet and half-feet, was used as a guide to the spacing intervals, but was soon replaced by eye appraisal. Occasional check measurements of the intervals were made, but no marked deviation was apparent. Thinning was carried out at the rate of a block per day and was completed by October 26th.

A hand-operated miniature rotary cultivator (fig. 5) was employed for inter-row cultivation; cultivation beyond that necessary to control weeds was not undertaken. The procedure with the cultivator was to cultivate between pairs of rows twice, following the edge of one plant row closely first and then the other plant row. When the plant leaves were beginning to meet across the rows, further weed control was effected by push hoe. A final weeding by hand of weeds growing higher than the marrow-stem kale plants was completed by December 7th and after this date, no further weeding was done. The most common weeds present were Chenopodium album, Coronopus didymus, Sinapis arvensis and Polygonum persicaria.

Meteorological Data

Figures for rainfall, evaporation from a free water surface, minimum grass temperature, soil temperature measured at 4-inch and 12-inch depths and the number of sunshine hours, for weekly intervals over the experimental period, are presented in Appendix 1. These figures were obtained from the records of Grasslands Division Meteorological Station, which was adjacent to the experimental area. The total rainfall, the number of days on which rain fell and the number of sunshine hours over the experimental period, together with the average figures for the equivalent period, abstracted from Grassland Division's records since observations began in 1928, are presented in Table IV.

Table IV

Total Rainfall, Number of Rain Days and Sunshine Hours for the Experimental Period, 16/9/56 - 24/3/57, and the 29-year Average for the Equivalent Period

	Rainfall Inches	No. of Rain Days	Sunshine Hours
Experimental period	21.35	83	1291.5
29-year average	20.28	85	1126.9

The experimental period therefore received just over one inch, or approximately 5%, more rain on two less days, and 164.6 hours, or approximately 15%, more sunshine than the 29-year average for the equivalent period.

(b) Experimental Procedure

Sampling Regime

To allow the paddock to be sown down to pasture and established before the onset of winter, it was necessary for the experiment to be finished by April. The sampling period decided upon was ten weeks in length, from 11th January to 22nd March 1957. This corresponded closely to the normal summer period of marrow-stem kale utilization to supplement dairy pastures. A total of twenty-four samples was available in each plot.

In order to obtain an estimate of the number of samples per plot required to give a reasonable detectable difference between treatments, four samples per plot were taken at random on the first sampling date, 11th January. Each sample of twelve feet consisted of paired 6-foot row lengths. Statistical examination showed green matter yields to have a coefficient of variation of 16.3%. Consequently it was calculated that treatment differences detectable at a 5% level of significance would be approximately 25%, 17%, 14%, 12%, 11% and 10% for 1, 2, 3, 4, 5 and 6 samples per plot respectively. Three samples per plot gave a detectable difference of 14% and thereafter the gain from increasing the number of samples was small. It was therefore decided that three samples per plot was a satisfactory number. The sampling regime was as follows, with 10-day intervals between sampling dates.

Sampling No.	Sampling Date	Samples Per Plot
1	11th Jan.	4
2	21st Jan.	3
3	31st Jan.	3
4	10th Feb.	3
5	20th Feb.	3
6	2nd Mar.	3
7	12th Mar.	3
8	22nd Mar.	2

Sampling Technique

The randomly-drawn samples were located by measuring off the required distance from the bottom of the sample rows. A six-foot long wooden pole was used to mark off the actual sample lengths, which were then cut with a sickle at a height of two inches above ground level. By cutting at this height, the extremely woody bases of the plants were excluded. After removal, the sample was weighed. This was done by use of a canvas sheet, a tripod and a spring balance which could be read to an accuracy of 0.25 pounds (fig.6).

The sample was divided into the following component parts:

(i) Upper leaf
(ii) Lower leaf
(iii) Upper stem
(iv) Lower stem

Each plant from the sample was cut at the mid-point of the stem; leaf and stem above this point were termed "upper" whilst leaf and stem below were termed "lower". The mid-point of the stem was found by placing the plant along a flat board, marked out in measured lengths and the cut made with a heavy-bladed kitchen knife (fig.7). The leaves were stripped off the stem by hand

Figure 6

Tripod, Spring Balance and Canvas Sheet for Weighing Samples. Also 6-foot Pole to Mark Off Sample Lengths and Sickle for Cutting.

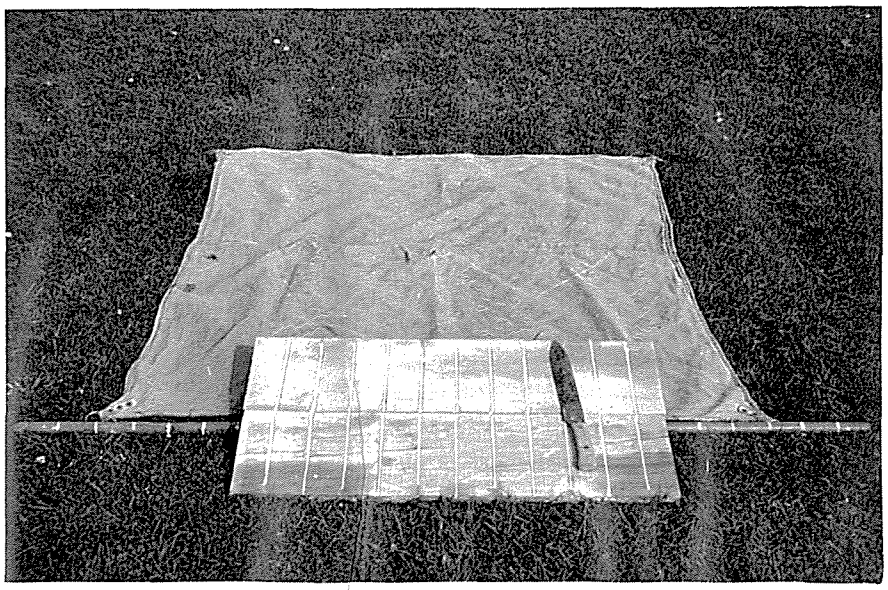


Figure 7

Board, Marked in Measured Lengths, and Knife for Dividing Plants into Component Parts

and this method resulted in a clean break between leaf petiole and stem. The component parts of the respective samples were weighed individually and the summed weights provided a check on the first weight of the total sample.

Dry Matter Content

From each of the sample component parts, a representative sub-sample was drawn for dry matter content determinations. These sub-samples were stored in separate plastic containers and kept in the shade. This procedure was repeated on every plot sample taken. The sub-samples of each component part from all the samples in any one plot were bulked. This was done as it was not practicable to determine dry matter contents of the component part sub-samples from every plot sample. Each block therefore supplied a total of twelve sub-samples i.e. one sub-sample from each of the three treatments. Blocks were sampled at the rate of two per day except during the palatability and digestibility trials with sheep, when the rate was one per day. To shorten the period of storage in the field and prevent excessive wilting, sub-samples were taken to the drying-oven as soon as the sampling of one block was completed.

Dry matter determinations were made in duplicate. From each sub-sample, two representative 300-gram laboratory samples were weighed into metal trays. To ensure representative sampling and to facilitate the drying-out process, stem samples were chopped into short lengths and split into slivers with a knife, before the laboratory sample was drawn. Laboratory samples of leaves were drawn from the whole leaves, but when necessary, large fleshy

petioles were split with a knife to aid drying-out. The trays of material were dried in a forced-draught type of hot air oven at 173°F for twelve hours. Upon removal from the drying oven, the tray samples were weighed immediately; dry matter weights were therefore expressed on a moisture-free basis. This method was preferred to that of allowing the samples to cool to a constant moisture content before weighing and expressing the results as air-dried weights. All weighings were made on an E.T.A. Triple Beam Balance, which could be read to an accuracy of 0.1 grams.

The resulting dry matter percentages, each averaged from two determinations, were combined with the summed green matter weights of the plot samples to give dry matter weights per summed plot sample.

The laboratory samples from sampling dates 11th Jan., 31st Jan., 20th Feb. and 12th Mar. were ground in a laboratory mill after drying and stored in sealed glass jars for future chemical analyses.

Collection of Data

The following information was recorded during the experiment:

(a) General observations of growth.

(b) Green matter yields of:

(i) Whole-plant samples.
(ii) Upper-leaf samples.
(iii) Lower-leaf samples.
(iv) Upper-stem samples.
(v) Lower-stem samples.

(c) Leaf percentage[1] (green matter basis).

(d) Dry matter percentages of:

(i) Upper leaf.
(ii) Lower leaf.
(iii) Upper stem.
(iv) Lower stem.
(v) Whole plant (by calculation).

(e) Dry matter yields of:

(i) Whole-plant samples.
(ii) Upper-leaf samples.
(iii) Lower-leaf samples.
(iv) Upper-stem samples.
(v) Lower-stem samples.

(f) Leaf percentage (dry matter basis).

[1]The leaf percentage is defined as:

$$\frac{\text{Weight of Total Leaf}}{\text{Weight of Total Leaf} + \text{Total Stem}} \times 100$$

(c) Experimental Results

The experimental results will be presented in five sections as follows:

(i) General observations of growth during the experimental period.

(ii) Whole plant and component-part green matter yields.

(iii) Whole plant and component-part dry matter yields.

(iv) Leaf percentages (green matter basis).

(v) Leaf percentages (dry matter basis).

In the presentation of the results, tables of original data and details of statistical analyses of these data are placed in the appendix where possible. Tables of mean values, together with the results of statistical tests are presented in the body of the thesis.

Certain conventional abbreviations will be used. These abbreviations and their full meanings are as follows:

Ut = unthinned marrow-stem kale.
St = 6" thinned marrow-stem kale.
Tt = 12" thinned marrow-stem kale.
F = the variance ratio, for specified conditions.

Mean = the mean value for specified characters.

S.E. = the standard error.

N.S. = result not statistically significant.

* = result statistically significant at the .05 (or 5%) level.

** = result statistically significant at the .01 (or 1%) level.

$d_{.05}$ = difference required between two means for that difference to be significant at the .05 (or 5%) level.

$d_{.01}$ = difference required between two means for that difference to be significant at the .01 (or 1%) level.

With reference to the leaf percentage data, it was considered that the percentages did not vary widely enough to warrant angular transformation (angle = arc sin $\sqrt{\text{percentage}}$) before statistical examination of the data (Snedecor, 1946, pp.431 et seq.).

(i) General Observations

The methods of weed control employed were effective in preventing serious competition from weeds throughout the trial.

In November, small patches of marrow-stem kale appeared to be of a lighter green colour and to be slightly shorter than the main body of the crop. These symptoms were also discernible in a crop of soft turnips growing adjacent to the experimental area. The condition disappeared after the heavy rainfall and subsequent rapid growth in late December. Sample plants showing the symptoms together with "normal" plants were taken from the border of the experimental area in November for crude protein analyses. Crude protein values were almost three per cent lower in the light green plants than in the others. In conjunction with the observation of Nalson (1957) that prior to ploughing, clover growth was not uniform in the paddock in which the experimental area was situated, the above factors suggested temporary nitrogen deficieney as a possible explanation. On the other hand, it is difficult to envisage this nitrogen deficiency in view of the heavy concentration of stock carried by the paddock in the winter of 1956 and which would supply considerable dung and urine to the soil. The patches may also have been the sites of feeding troughs though. The disappearance of the condition after heavy rainfall suggests movement of soil nitrogen.

Growth received a stimulus from the heavy rainfall in late December and early January, especially as the rain was followed by long periods of sunshine (Appendix 1). Leaf shedding was most evident after the unplanted space between the rows was over-shadowed by marrow-stem kale growth, suggesting

that lack of light may be a contributory factor.

Differences between the treatments in vegetative growth characteristics became manifest within a few weeks of thinning being completed. Unthinned marrow-stem kale was characterised by tall thin stems with most of the leaf growth concentrated near the top of the plant; 12" thinned was less tall, had much thicker stems and leaf growth extended fairly well down the stem; 6" thinned was intermediate. These differences were substantially maintained throughout the experimental period. Examples of the type of vegetative growth of unthinned, 6" thinned and 12" thinned marrow-stem kale are shown in figures 8, 9 and 10 respectively. The crop still appeared to be growing actively at the termination of the experimental period.

Transverse sections of the stems of the three treatment types were examined by use of a low-power (10 x) binocular microscope. Stems from the unthinned treatment showed narrow bands of woody xylem and marrow centres small in area, whilst stems from the 12" thinned treatment showed wide xylem bands with marrow centres large in area; the 6" thinning treatment was intermediate. Sections from all treatment types, taken just above ground level, showed solid xylem throughout. The thickness of xylem decreased gradually up the stem and near the top, became very thin.

Figure 8

Unthinned
Marrow-stem Kale

Figure 9

6" thinned
Marrow-stem Kale

Figure 10

12" thinned
Marrow-stem Kale

(All photographed from a distance of 6' on 2nd. March 1957)

(11) Green Matter Yields

The green matter weights recorded for each plot (whole plant) sample, together with individual green matter weights recorded for the component parts of each sample, at each sampling date, are presented in tabular form in Appendix 2. The mean green matter weights per plot sample and per component-part sample, calculated from the total number of samples taken from each treatment type of marrow-stem kale, at each sampling date, are shown in graphical form in figure 11.

To elucidate the relationship between the yields from different treatments, individual analyses of variance (Snedecor, 1956, pp.291 et sqq.) were carried out on the plot sample yields and each of their component-part yields, at each sampling date. The relevant details of these analyses are set out in Table V. Yields of lower leaf were not analysed statistically after the second sampling date, as thereafter, particularly in the unthinned and 6" thinned treatments, lower leaf was absent in many of the plot samples.

Comparison of the plot sample yields from the three treatments showed that no one treatment held yield superiority consistently over the sampling period; unthinned marrow-stem kale had the greatest yield on four sampling dates and the other treatment types on two sampling dates each. Treatment yields for upper leaf were in the descending order of 12" thinned, unthinned and 6" thinned respectively, at the majority of the sampling dates, though,on a sample basis, the differences between

Table V

Table V

Results of Analyses of Variance for Plot, Component-Part and Total-Leaf Sample Green Matter Yields at each Sampling Date

Sampling Date (1957)	Treatment Means Ut	St	Tt	S.E.s of Means	F Value[1]	F Result	Treatment Means Ut	St	Tt	S.E.s of Means	F Value[1]	F Result	Treatment Means Ut	St	Tt	S.E.s of Means	F Value[1]	F Result
	Whole Plant						Upper Leaf						Upper Stem					
Jan.11	44.1	42.6	44.0	±2.6	0.11	N.S.	14.5	14.0	15.9	±1.0	0.94	N.S.	13.5	11.0	10.6	±0.9	3.07	N.S.
Jan.21	47.5	44.3	46.1	±2.4	0.47	N.S.	14.5	14.4	15.2	±0.6	0.48	N.S.	15.4	12.5	13.3	±1.1	1.94	N.S.
Jan.31	48.5	47.2	49.0	±2.3	0.18	N.S.	14.5	14.0	15.4	±0.6	1.40	N.S.	15.3	14.5	15.0	±1.0	0.19	N.S.
Feb.10	51.2	51.9	49.9	±2.6	0.15	N.S.	14.3	13.8	15.3	±0.7	1.03	N.S.	17.6	17.2	15.2	±1.0	1.59	N.S.
Feb.20	54.2	53.9	54.0	±1.8	0.01	N.S.	13.0	12.6	14.1	±0.5	2.79	N.S.	20.5	19.2	18.2	±0.8	1.89	N.S.
Mar. 2	63.0	57.9	60.7	±2.6	0.95	N.S.	15.2	14.2	15.3	±0.8	0.67	N.S.	24.7	20.8	21.8	±1.2	2.68	N.S.
Mar.12	64.9	68.0	63.2	±3.5	0.49	N.S.	15.4	15.6	16.6	±0.8	0.60	N.S.	25.7	25.7	23.1	±1.7	0.86	N.S.
Mar.22	67.1	68.3	70.6	±2.4	0.53	N.S.	15.4	14.2	15.5	±0.7	0.96	N.S.	26.3	26.3	26.4	±0.7	0.01	N.S.
	Total Leaf						Lower Leaf						Lower Stem					
Jan.11	16.0	17.3	20.5	±1.0	4.89	N.S.	1.5	3.4	4.6	±0.3	53.16	**[2]	14.6	14.4	13.1	±1.0	0.78	N.S.
Jan.21	15.0	16.0	17.1	±0.7	2.23	N.S.	0.5	1.6	1.9	±0.3	4.94	N.S.	17.3	16.2	16.4	±0.9	0.40	N.S.
Jan.31	15.2	14.6	16.3	±0.8	1.12	N.S.							18.1	18.2	17.9	±0.9	0.05	N.S.
Feb.10	14.5	14.3	16.1	±0.8	1.47	N.S.							19.2	20.4	18.7	±1.1	0.73	N.S.
Feb.20	13.2	13.0	14.5	±0.6	1.66	N.S.							20.6	21.8	21.4	±0.8	0.54	N.S.
Mar. 2	15.2	14.2	17.5	±1.2	2.04	N.S.							23.1	22.9	23.5	±0.9	0.14	N.S.
Mar.12	15.4	15.6	16.7	±0.8	0.82	N.S.							23.8	26.8	23.5	±1.4	1.63	N.S.
Mar.22	15.4	14.2	15.5	±0.7	0.96	N.S.							25.4	27.8	28.8	±1.0	2.75	N.S.

[1] F required, .05 (.01) = 5.14 (10.92)

[2] In addition, Regression **
Deviation N.S.

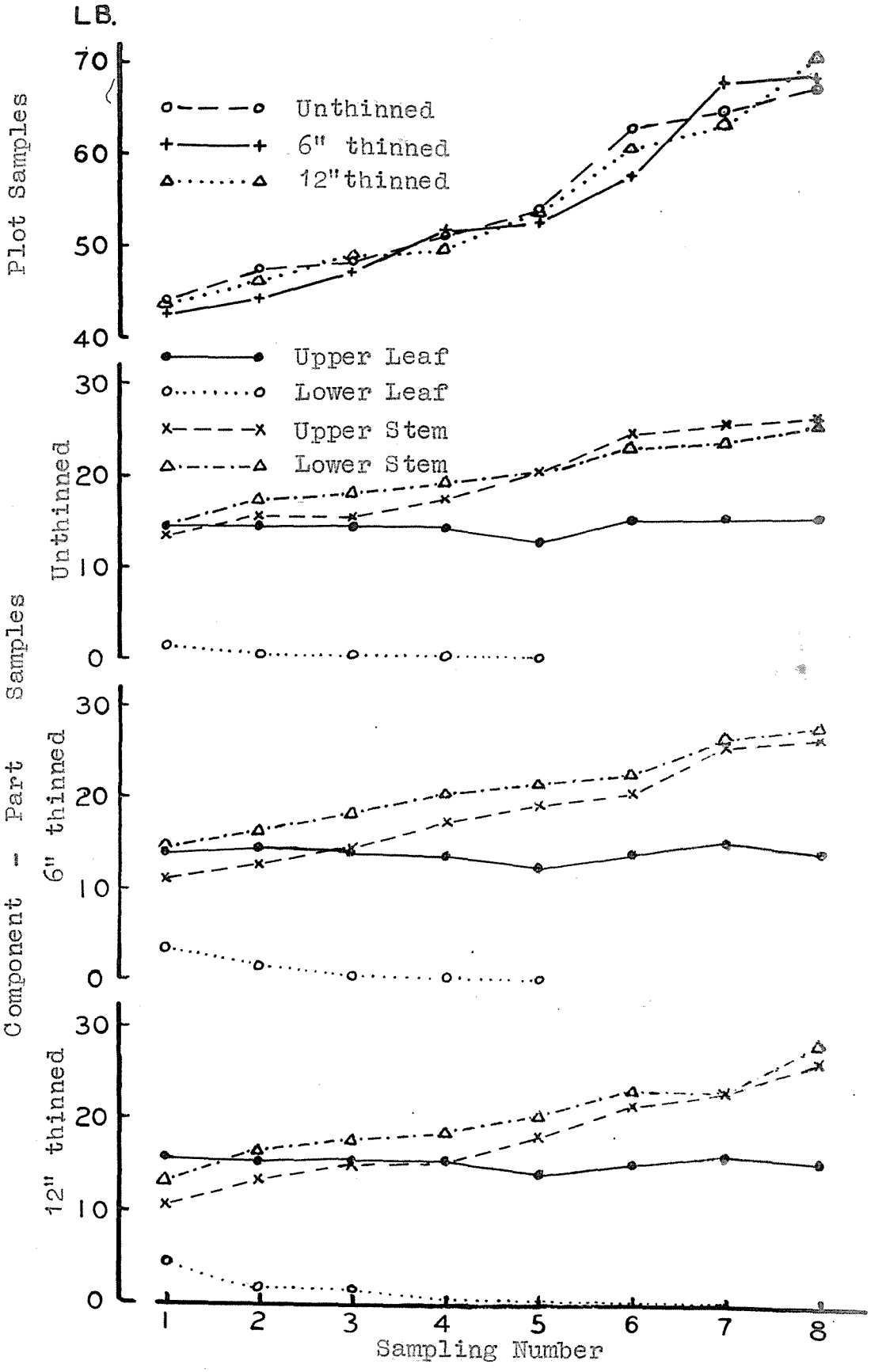


Figure 11

Mean Green Matter Weights per Plot Sample and per Component-Part Sample of the Three Treatments (12' sample)

(Multiply by 2074.3 to obtain yield per acre)

treatments were always less than two pounds weight. Yields of lower leaf indicated a trend of increasing yields with increasing severity of thinning. Total-leaf yields, that is, a combination of upper-leaf and lower-leaf yields, followed the order as above for upper leaf. With the upper-stem component, the unthinned treatment yields were consistently slightly greater than those of the other two treatments; these latter two did not differ by much. In the case of yields of lower stem, no one treatment held yield superiority consistently over the sampling period.

Reference to Table V showed that in every case but one, treatment differences in the plot and component-part sample yields were not significant. The exception was the lower-leaf component at the first sampling date, when the treatment yields differed significantly and also showed a significant linear regression -- with non-significant deviation -- of increasing yields with increasing severity of thinning.

The general pattern of yield over the sampling period for plot and component-part samples in each treatment was essentially similar. Yields from the plot samples increased fairly steadily from the first to the last sampling date. Upper-leaf yields tended to remain approximately level over the sampling period, but lower-leaf yields, which were never very high, decreased to zero in all treatments before the end of the sampling period. Upper-stem and lower-stem yields increased over the sampling period. Consequently, after a short initial period, during which upper-leaf, upper-stem and lower-stem yields respectively, were fairly similar, both stem-component yields

overtook those of upper leaf. This occurred in all treatments at varying times during the first half of the sampling period. At the majority of the sampling dates, lower-stem yields were greater than upper-stem yields in all three treatments; the difference on a sample basis was frequently less than four pounds weight. The range of green matter yields on a tons per acre basis for whole-plant and component-part samples of each treatment over the sampling period, is presented in Table VI.

To establish the relationship between yields of plot and component-part samples from the three treatment types of marrow-stem kale over the sampling period, analyses of variance were carried out on these respective sample yields and on total-leaf yields, over all the sampling dates. This was done by use of the split-plot type of experimental design (Snedecor, 1956, pp.366 et sqq.); the main plot analysis was that of randomized blocks with three treatments replicated in four blocks and the sub-plot analysis was that of eight dates of sampling randomized in each of the twelve main plots. The analyses of variance are set out in Appendix 3 and the relevant details of these analyses presented in Table VII. Lower-leaf yields were not analysed because of their inconsistency after the second sampling date.

The results from the analyses showed that the differences between treatment means for plot and component-part sample yields were non-significant in all cases. For total-leaf yields, the differences between treatment means were significant and a t-test demonstrated that the 12" thinned

Table VI

Range of Green Matter Yields (means) for Whole-Plant and Component-Part Samples of each Treatment Type of Marrow-stem Kale over the Sampling Period, 11th Jan. to 22nd Mar., 1957

(tons per acre)

Treatment	Whole Plant		Upper Leaf		Lower Leaf		Upper Stem		Lower Stem	
	Jan. 11	Mar. 22	Jan. 11	Mar. 22	Jan. 11	Mar. 22	Jan. 11	Mar. 22	Jan. 11	Mar. 22
Unthinned	40.8	62.1	13.4	14.2	1.4	-	12.5	24.4	13.5	23.5
6" thinned	39.4	63.2	12.9	13.1	3.1	-	10.1	24.4	13.3	25.7
12" thinned	40.7	65.4	14.7	14.3	4.1	-	9.8	24.4	12.1	26.7

Table VII

Results of Analyses of Variance for Plot, Component-Part and Total-Leaf Sample Green Matter Yields over all Sampling Dates

Treatment \ Sample	Plot Sample	Upper Leaf	Total Leaf	Upper Stem	Lower Stem
	(a) Treatment Means				
Unthinned	55.1	14.6	15.0	19.9	20.3
6" thinned	54.3	14.1	14.9	18.4	21.1
12" thinned	54.7	15.4	16.8	17.6	20.4
S.E.s of means	±1.8	±0.4	±0.4	±0.7	±0.4
F test results	N.S.	N.S.	*	N.S.	N.S.
d reqd. .05	-	-	1.1	-	-
Date (1957)	(b) Date Means				
Jan. 11	43.6	14.8	18.0	11.7	14.1
Jan. 21	46.0	14.7	16.0	13.7	16.6
Jan. 31	48.3	14.6	15.4	15.0	18.1
Feb. 10	51.0	14.4	15.0	16.7	19.4
Feb. 20	54.0	13.2	13.5	19.3	21.3
Mar. 2	60.5	14.9	15.6	22.4	23.2
Mar. 12	65.4	15.9	15.9	24.8	24.7
Mar. 22	68.7	15.1	15.1	25.5	27.3
S.E.s of means	±1.2	±0.4	±0.5	±0.5	±0.5
F test result	**	**	**	**	**
Regression	**	-	-	**	**
Deviation	N.S.	-	-	N.S.	N.S.
d reqd. .05(.01)	-	1.1(1.5)	1.4(1.9)	-	-

treatment mean was significantly greater than the means for the other two treatments. Differences between date means were significant for plot, all component - part and total-leaf sample yields. Further, in the case of plot, upper-stem and lower-stem sample yields respectively, the means showed significant linear regressions — with non-significant deviations — of increasing yields with time.

(iii) Dry Matter Yields

The dry matter weights recorded for each summed plot sample together with individual dry matter weights recorded for the summed component parts of each sample, at each sampling date, are presented in tabular form in Appendix 4. The mean dry matter weights per summed plot sample and per summed component-part sample, calculated from the total number of summed samples taken from each treatment type of marrow-stem kale, at each sampling date, are graphically shown in figure 12. The means for the first and eighth sampling dates, when four and two samples per plot respectively were taken, were adjusted to a three samples

Table VIII

Table VIII

Results of Analyses of Variance for Plot, Component-Part and Total-Leaf

Sample Dry Matter Yields at each Sampling Date

Sampling Date (1957)	Treatment Means Ut	St	Tt	S.E.s of Means	F Value[1]	F Result	Treatment Means Ut	St	Tt	S.E.s of Means	F Value[1]	F Result	Treatment Means Ut	St	Tt	S.E.s of Means	F Value[1]	F Result
	Whole Plant						Upper Leaf						Upper Stem					
Jan.11	18.8 (14.1)	19.0 (14.3)	18.1 (13.5)	±1.9	0.14	N.S.	6.9 (5.2)	7.4 (5.6)	7.7 (5.8)	±0.5	0.61	N.S.	4.5 (3.4)	3.5 (2.7)	3.4 (2.5)	±0.3	4.50	N.S.
Jan.21	16.8	15.9	15.9	±1.5	0.29	N.S.	5.7	6.1	6.5	±0.3	1.65	N.S.	4.6	3.4	3.5	±0.2	7.70	*4
Jan.31	17.2	17.3	17.1	±1.1	0.02	N.S.	5.9	5.8	6.5	±0.2	3.05	N.S.	4.4	4.6	3.8	±0.4	1.36	N.S.
Feb.10	19.5	18.4	17.0	±1.1	2.63	N.S.	6.3	6.0	6.5	±0.3	0.90	N.S.	5.4	4.7	4.3	±0.3	3.75	N.S.
Feb.20	21.5	18.2	20.0	±0.8	8.93	*2	5.9	5.2	6.1	±0.3	3.12	N.S.	7.0	5.4	5.1	±0.3	10.78	*5
Mar. 2	24.3	21.6	20.4	±1.5	3.49	N.S.	6.5	6.0	6.0	±0.4	0.59	N.S.	8.4	6.4	5.3	±0.3	26.89	**3
Mar.12	24.4	23.5	22.7	±1.9	0.35	N.S.	6.4	6.1	7.0	±0.4	1.15	N.S.	8.1	7.5	7.0	±0.4	1.71	N.S.
Mar.22	18.9 (28.4)	16.9 (25.4)	16.9 (25.3)	±1.6	1.07	N.S.	4.4 (6.5)	3.9 (5.8)	4.1 (6.1)	±0.2	1.08	N.S.	6.5 (9.7)	5.6 (8.5)	5.0 (7.5)	±0.5	1.86	N.S.
	Total Leaf						Lower Leaf						Lower Leaf					
Jan.11	7.5 (5.6)	8.8 (6.6)	9.5 (7.1)	±0.5	3.30	N.S.	0.6 (0.5)	1.4 (1.1)	1.8 (1.3)	±0.1	66.00	**3	6.8 (5.1)	6.7 (5.0)	5.2 (3.9)	±0.6	2.05	N.S.
Jan.21	5.9	6.6	7.1	±0.3	3.12	N.S.	0.2	0.5	0.6	±0.1	5.00	N.S.	6.3	5.9	5.4	±0.6	0.61	N.S.
Jan.31	6.1	6.0	6.9	±0.3	2.59	N.S.	0.2	0.2	0.3	±0.1	0.50	N.S.	6.7	7.2	6.4	±0.6	0.39	N.S.
Feb.10	6.4	6.1	6.8	±0.3	1.29	N.S.							7.9	7.5	5.9	±0.5	4.63	N.S.
Feb.20	5.9	5.4	6.2	±0.3	3.12	N.S.							8.6	7.4	8.7	±0.4	3.04	N.S.
Mar. 2	6.5	6.0	6.0	±0.4	0.59	N.S.							9.4	9.2	9.1	±0.9	0.03	N.S.
Mar.12	6.4	6.1	7.0	±0.4	1.15	N.S.							9.9	10.0	8.7	+1.2	0.42	N.S.
Mar.22	4.4 (6.5)	3.9 (5.8)	4.1 (6.1)	±0.2	1.08	N.S.							8.1 (12.2)	7.4 (11.1)	7.8 (11.7)	±0.5	0.44	N.S.

[1] F required, .05(.01) = 5.14(10.92)

[2] d required, .05 = 1.9

[3] In addition, Regression **
Deviation N.S.

[4] d required, .05 = 0.8

[5] d required, .05 = 1.1

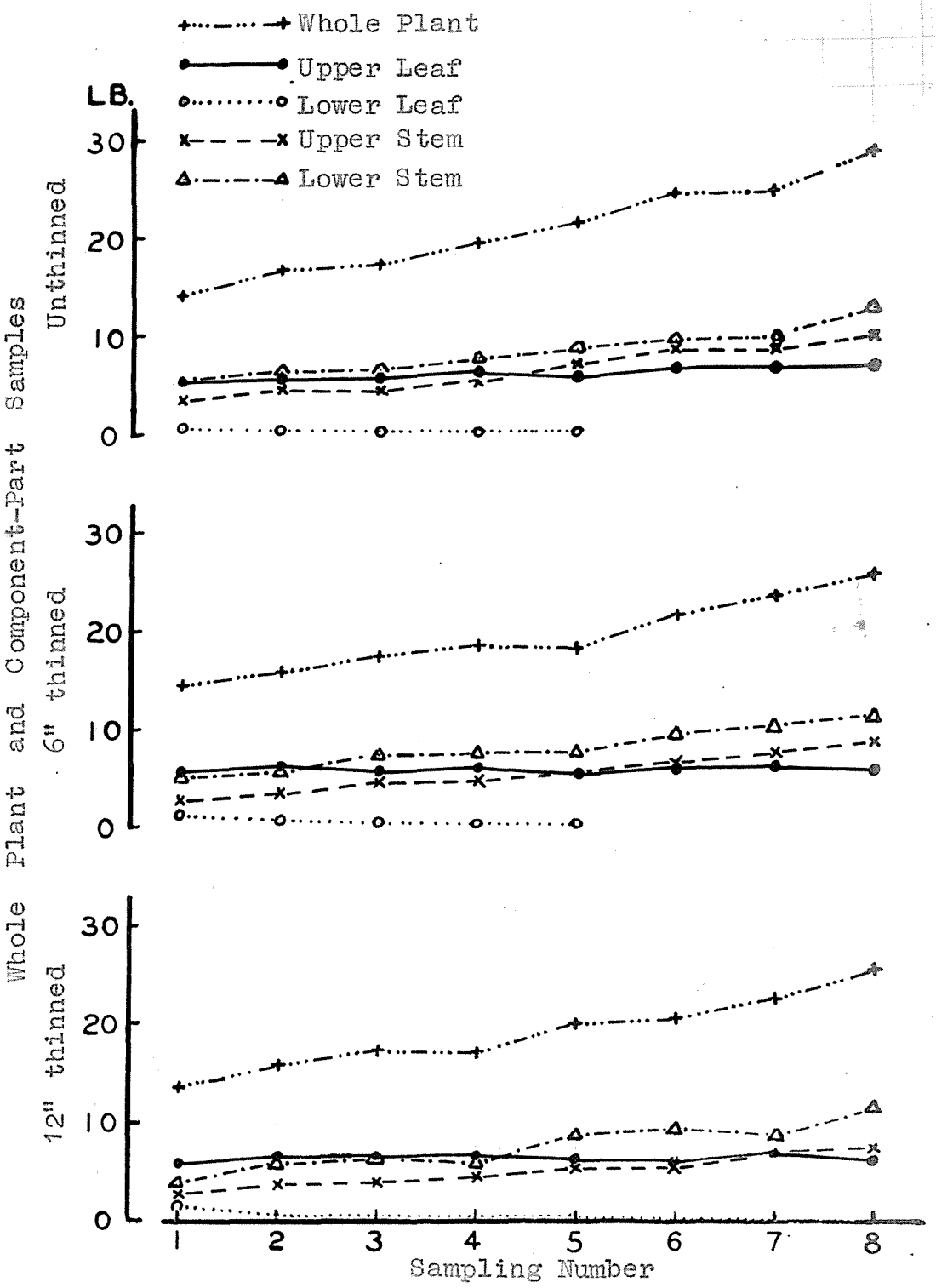


Figure 12

Mean Dry Matter Weights per Summed Plot Sample and per Summed Component-Part Sample of the Three Treatments (36' sample)
(Multiply by 691.4 to obtain yield per acre)

per plot basis, in order to be directly comparable with the means for the other sampling dates; these adjusted means are shown in brackets in Table VIII.

To define the relationship between the yields from different treatments, individual analyses of variance were carried out on the summed plot sample yields and each of their summed component-part yields, at each sampling date. These analyses of variance differed from those done on the green matter weights in that no within plot variation could be separately taken out; this was due to summing of the plot samples for the dry matter estimations. The summarized results of the analyses are set out in Table VIII. Yields of lower leaf were not analysed beyond the third sampling date due to their inconsistency.

Inspection of the data showed that unthinned marrow-stem kale had frequently the greatest summed plot sample yield during the sampling period, whilst 12" thinned had frequently the lowest yield. The trend was therefore one of decreasing dry matter yields with increasing severity of thinning. However, the treatment differences were not marked and only attained significance at the fifth sampling date. Treatment yields for upper leaf were in the descending order of 12" thinned, unthinned and 6" thinned respectively, at the majority of the sampling dates; the differences on a summed plot basis were however less than one pound weight. Yields of lower leaf indicated a trend of increasing yields with increasing severity of thinning. Total-leaf yields followed the order as above for upper leaf. The treatment differences were non-significant at all sampling dates in the case of upper leaf

and total leaf. Lower-leaf treatment yields differed significantly at the first sampling date only and also showed a significant linear regression — with non-significant deviation — of increasing yields with increasing severity of thinning. Treatment differences for lower stem did not attain significance at any of the sampling dates. With the upper-stem component, significance was attained at the second, fifth and sixth sampling dates; at the latter of these dates, the treatment means further showed a significant linear regression — with non-significant deviation — of decreasing yields with increasing severity of thinning.

The general pattern of yield over the sampling period for summed plot and component-part samples in each treatment was essentially similar. Thus, in all treatments, summed plot sample yields increased fairly steadily from the first to the last sampling date, whilst in the same period, upper-leaf and total-leaf yields did not fluctuate very much; lower-leaf yields, which were always very low, decreased to zero before the end of the sampling period. Both stem components increased in yield over the sampling period and consequently, although both had lower yields than the upper-leaf component at the beginning of the sampling period in all treatments, they both eventually outyielded the upper leaf. This occurred within the first half of the sampling period in the case of lower stem whilst upper stem, which was consistently lower in yield than lower stem, took longer to outyield upper leaf. The range of dry matter yields on a tons per acre basis for whole plant and component-part samples of

each treatment over the sampling period is presented in Table IX.

Summed plot, component-part and total-leaf dry matter yields respectively were each adjusted to a mean individual plot sample yield basis (that is, a similar basis to that of the green matter yields) before subjecting the yields over all the sampling dates to analyses of variance. As before, the split-plot type of experimental design was used. The analyses are set out in Appendix 5 and the relevant details of these analyses are summarized in Table X. Yields of lower leaf were not analysed because of their inconsistency.

These results showed that the differences between treatment means for plot, upper leaf, total leaf and lower stems respectively, were not significant. The means differed significantly in the case of the upper-stem component though and in addition showed a significant linear regression — with non-significant deviation — of decreasing yields with increasing severity of thinning. Differences between date means were significant in the plot, upper-leaf and both stem-component samples. Further, in all these samples except upper leaf, the treatment means showed significant linear regressions — with non-significant deviations — of increasing yields with time. The date means for total-leaf yields did not differ significantly.

Table IX

Range of Dry Matter Yields (means) for Whole-Plant and Component-Part Samples of each Treatment Type of Marrow-stem Kale over the Sampling Period, 11th Jan. to 22nd Mar., 1957

(tons per acre)

Treatment	Whole Plant		Upper Leaf		Lower Leaf		Upper Stem		Lower Stem	
	Jan. 11	Mar. 22	Jan. 11	Mar. 22	Jan. 11	Mar. 22	Jan. 11	Mar. 22	Jan. 11	Mar. 22
Unthinned	4.4	8.8	1.6	2.0	0.1	-	1.1	3.0	1.6	3.8
6" thinned	4.4	7.8	1.7	1.8	0.3	-	0.8	2.6	1.6	3.4
12" thinned	4.2	7.8	1.8	1.9	0.4	-	0.8	2.3	1.2	3.6

Table X

Results of Analyses of Variance for Plot, Component-Part and Total-Leaf Sample Dry Matter Yields over all Sampling Dates

Treatment \ Sample	Plot Sample	Upper Leaf	Total Leaf	Upper Stem	Lower Stem
	(a) Treatment Means				
Unthinned	6.9	2.0	2.1	2.1	2.8
6" thinned	6.5	1.9	2.0	1.8	2.6
12" thinned	6.3	2.1	2.2	1.6	2.5
S.E.s of means	±0.2	±0.1	±0.1	±0.1	±0.2
F test result	N.S.	N.S.	N.S.	**	N.S.
Regression	-	-	-	**	-
Deviation	-	-	-	N.S.	-
Date (1957)	(b) Date Means				
Jan. 11	4.7	1.8	2.2	1.0	1.6
Jan. 21	5.3	2.0	2.2	1.3	2.0
Jan. 31	5.7	2.0	2.1	1.4	2.3
Feb. 10	6.1	2.1	2.1	1.6	2.4
Feb. 20	6.7	1.9	2.0	1.9	2.8
Mar. 2	7.4	2.1	2.1	2.2	3.1
Mar. 12	7.9	2.2	2.2	2.5	3.2
Mar. 22	8.8	2.1	2.1	2.9	3.9
S.E.s of means	±0.2	±0.1	±0.1	±0.1	±0.2
F test result	**	**	N.S.	**	**
Regression	**	-	-	**	**
Deviation	N.S.	-	-	N.S.	N.S.
d reqd. .05(.01)	-	.16(.22)	-	-	-

(iv) Leaf Percentage (green matter basis)

The leaf percentages for each plot sample at each sampling date are tabulated in Appendix 6, whilst the mean leaf percentages per plot sample, calculated from the total number of samples taken from each treatment type of marrow-stem kale, at each sampling date, are graphically presented in figure 13.

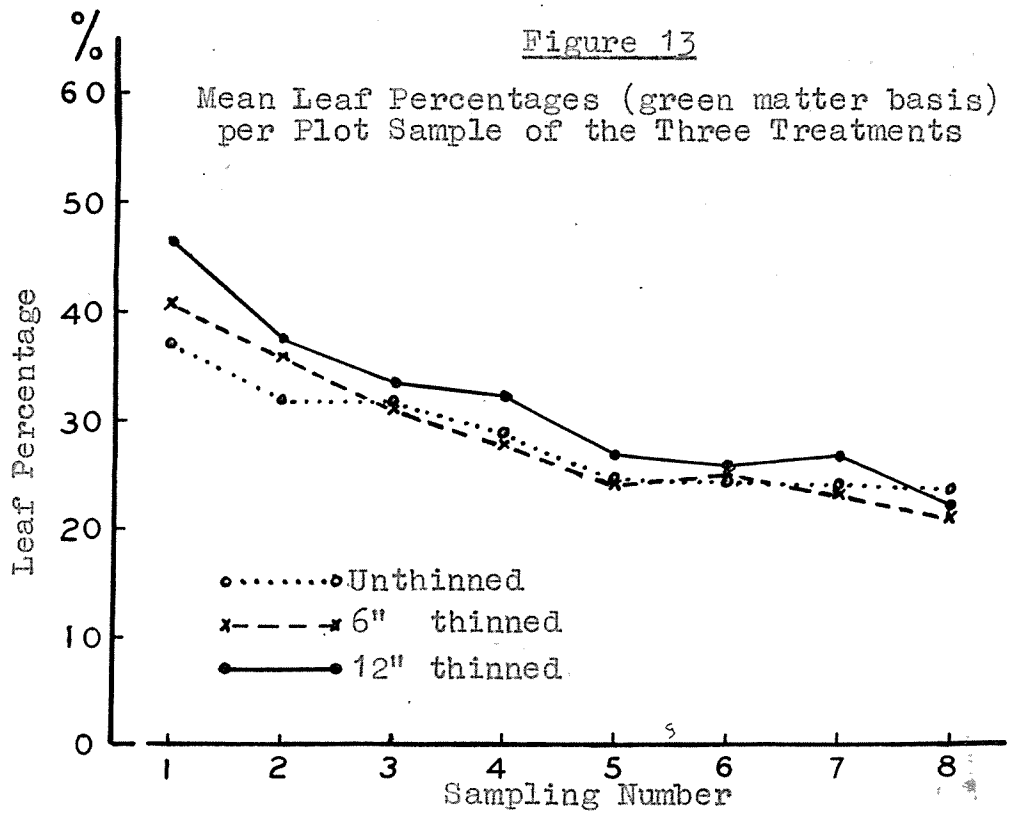
To interpret the differences between leaf percentages resulting from the different treatments, analyses of variance were carried out on the leaf percentages at individual sampling dates. The results from these analyses are summarized in Table XI.

The differences in leaf percentage between the treatments were well marked at the beginning of the sampling period; 12" thinned marrow-stem kale had the highest leaf percentage, followed by 6" thinned and lastly unthinned. From the middle of the sampling period onwards, however, the differences tended to be small and by the final sampling date, the differences between treatments were less than three per cent. Reference to Table XI showed significant differences between treatments at the first, second, fifth and seventh sampling dates. Further, at the former two of these dates, the means showed significant regressions — with non-significant deviations — of increasing leaf percentages with increasing severity of thinning. Thereafter, no consistent trend was followed, except that the 12" thinning treatment had slightly higher leaf percentages than the other treatments at all the sampling dates except the last one.

In all three treatments, there were trends of decreasing leaf percentages with time; the rate of decrease was greatest

Figure 13

Mean Leaf Percentages (green matter basis)
per Plot Sample of the Three Treatments



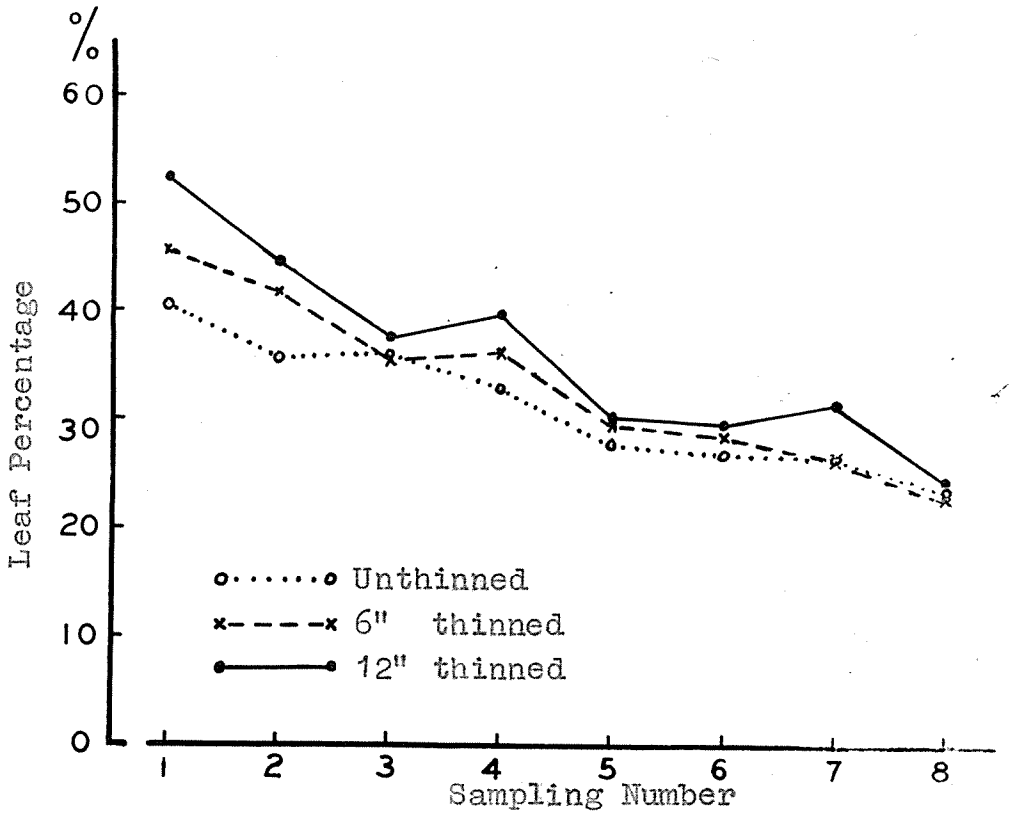


Figure 14

Mean Leaf Percentages (dry matter basis)
per Plot Sample of the Three Treatments

Table XI

Results of Analyses of Variance of Leaf Percentages
(green matter basis) at each Sampling Date

Treatment \ Date(1957)	Jan.11	Jan.21	Jan.31	Feb.10	Feb.20	Mar. 2	Mar.12	Mar.22
Unthinned	37.0	31.8	31.5	28.6	24.3	24.1	23.9	23.1
6" thinned	40.7	35.9	31.0	27.6	24.0	24.6	23.0	20.8
12" thinned	46.2	37.2	33.1	32.0	26.6	25.2	26.4	21.8
S.E.s of means	±0.9	±1.1	±1.2	±1.0	±0.83	±0.8	±0.6	±0.6
F value[1]	28.21	6.29	0.83	5.27	2.89	0.42	8.14	3.67
F test result	**	*	N.S.	*	N.S.	N.S.	*	N.S.
Regression	**	*	-	-	-	-	-	-
Deviation	N.S.	N.S.	-	-	-	-	-	-
d reqd, .05	-	-	-	3.4	-	-	2.1	-

[1] F required, .05 (.01) = 5.14 (10.92)

at the beginning of the sampling period, but was much slower towards the end.

To elucidate the relationship between leaf percentages from the three treatments over the sampling period, an analysis of variance was carried out on the leaf percentages over all sampling dates (Appendix 7). The relevant details of this analysis are shown in Table XII.

There were significant differences in leaf percentage between treatments and between dates, whilst there was also a significant dates x treatments interaction. The treatment means further demonstrated a significant linear regression — with non-significant deviation — of increasing leaf percentages with increasing severity of thinning. The interpretation of the interaction was that the differences between treatment means did not remain consistent over the sampling period, but varied so that the statistical significance of the treatment differences also changed. The exact nature of these changes was as already indicated by the results from the analyses of variance at each sampling date.

Table XII

Results from Analysis of Variance of Leaf Percentage (green matter basis) over all Sampling Dates

(a) Treatment Means

Leaf %	Treatment			S.E.s of Means	F Test Result	Regression	Deviation
	Ut	St	Tt				
Means	28.0	28.5	31.1	±0.5	**	**	N.S.

(b) Date Means

Leaf %	Jan. 11	Jan. 21	Jan. 31	Feb. 10	Feb. 20	Mar. 2	Mar. 12	Mar. 22	S.E.s of Means	F Test Result	d required .05	d required .01
Means	41.3	35.0	31.9	29.4	25.0	24.6	24.4	21.9	±0.5	**	1.2	1.7

(v) Leaf Percentage (dry matter basis)

The leaf percentages for each summed plot sample, at each sampling date, are tabulated in Appendix 8, whilst the mean leaf percentages per summed plot sample, calculated from the total number of samples taken from each treatment type of marrow-stem kale, at each sampling date, are graphically presented in figure 14.

To establish the differences between leaf percentages resulting from different treatments, analyses of variance were carried out on the leaf percentages at individual sampling dates. The relevant details of these analyses are presented in Table XIII.

In general, the differences in leaf percentage between treatments followed the same pattern as those of the leaf percentages on a green matter basis. The differences were greatest at the beginning of the sampling period, but by the final sampling date, were less than two per cent between treatments. The results from the analyses of variance showed that the treatments differed significantly at the first, second and fourth sampling dates. At these dates, the treatment means further showed significant linear regressions — with non-significant deviations — of increasing leaf percentages with increasing severity of thinning. This trend was not consistent throughout the sampling period, but at all sampling dates, the 12" thinning treatment had the highest percentage.

As with the leaf percentages on a green matter basis, all three treatments showed general trends of decreasing leaf

Table XIII

Results of Analyses of Variance of Leaf Percentages
(dry matter basis) at each Sampling Date

Treatment \ Date (1957)	Jan. 11	Jan. 21	Jan. 31	Feb. 10	Feb. 20	Mar. 2	Mar. 12	Mar. 22
Unthinned	40.4	35.6	36.0	32.9	27.6	26.8	26.2	23.3
6" thinned	45.8	41.8	35.3	36.2	29.4	28.2	26.1	22.8
12" thinned	52.4	44.6	37.5	39.7	31.0	29.5	31.3	24.2
S.E.s of means	±0.9	±2.1	±1.5	±1.2	±1.3	±2.6	±3.1	±1.4
F value[1]	46.97	10.12	0.59	18.50	3.69	0.57	1.89	0.50
F test result	**	*	N.S.	**	N.S.	N.S.	N.S.	N.S.
Regression	**	**	-	**	-	-	-	-
Deviation	N.S.	N.S.	-	N.S.	-	-	-	-

[1] F value required, .05 (.01) = 5.14 (10.92)

percentages with time; the greatest rate of decrease occurred at the beginning of the sampling period.

To define the relationship between leaf percentages from the three treatments over the sampling period, an analysis of variance was carried out on the leaf percentages over all sampling dates (Appendix 7). The results of this analysis are summarized in Table XIV.

There were significant differences between treatments and between dates, whilst there was also a significant dates x treatments interaction. The treatment means further demonstrated a significant linear regression — with non-significant deviation — of increasing leaf percentages with increasing severity of thinning. The significant interaction indicated that the treatment differences did not remain consistent over the sampling period. The precise nature of the changes in the treatment differences over the sampling period was as already demonstrated by the results from the analyses of variance at each sampling date.

Table XIV

Results from Analysis of Variance of Leaf Percentages
(dry matter basis) over all Sampling Dates

(a) Treatment Means

Leaf %	Treatment			S.E.s of Means	F Test Result	Regression	Deviation
	Ut	St	Tt				
Means	31.1	33.2	36.3	±0.4	**	**	N.S.

(b) Date Means

Leaf %	Jan. 11	Jan. 21	Jan. 31	Feb. 10	Feb. 20	Mar. 2	Mar. 12	Mar. 22	S.E.s of Means	F test Result	d required .05	d required .01
Means	46.2	40.7	37.3	36.3	29.3	28.2	27.9	23.4	±0.8	**	2.3	3.1

(d) Discussion of Results

From the viewpoints of ease of handling the material and of examination of the results, the experimental layout proved to be satisfactory. The number of replications was sufficient to allow reasonable differences between the treatments to be detected by statistical analyses; standard errors were fairly low, indicating that the variation in plant material was not marked.

The results showed that relative to not thinning, the thinned treatments employed did not affect the whole-plant green matter yields. This is in agreement with the results presented in Table 1 from Woodman et al. (1936), Fagan et al. (1945) and the Rothamsted Annual Reports (1932b, 1934, 1935, 1937, 1938a and b) for comparable thinning treatments. On the other hand the results were contrary to those quoted by Morrison and Hale (1936, 1937) and the Rothamsted Annual Reports (1933b, 1936). The present results also showed that the thinning treatments employed did not affect the whole-plant dry matter yields.

There has been much controversy in the past over the effect of plant population on yield and in spite of the volume of experimental work conducted, the problem is by no means solved. It is commonly stated that plant growth shows a "propinquity" effect; that is, yield from a very small area is largely affected by the competition its plants have to meet from surrounding areas. That thinning in the present trial and those referred to in Table 1 had no effect on yield, may be conceivably attributed in part to this propinquity effect, in that the wider spacing interval

between plants was compensated for by the extra growth of the plants. Since Table 1 also showed that thinning to 18" reduced yield, it is quite possible that a limit in spacing interval is reached where the compensatory effect cannot wholly make up for lack of plant population. In view of the fact that experiments comparing thinned and unthinned marrow-stem kale crop yields have given such contradictory results, it is obvious that the propinquity effect is not the only influencing factor.

It is interesting to compare the level of yields obtained in the current trial with those (all from European trials) presented in Table 1. In the present trial, green matter yields, from a growing period of four to six months, ranged from forty to sixty tons per acre in all three treatments. Overseas yields from a growing period of approximately six to eight months varied widely, ranging from ten to thirty-six tons per acre. Since current dry matter percentages were comparable with those obtained in several overseas trials, it may be assumed that total dry matter yields from the present trial would be at a higher level than overseas yields.

In search of an explanation of these yield differences, variation in climate between New Zealand and the European countries is probably a major factor. In addition, the present experimental area received more rain in fewer days and more sunshine than the 29-year average for the equivalent period. Seed variety and inherent fertility of the soil may be other contributory factors. The effective weed control employed in the present trial may also have been partly responsible, particularly in light of results from another trial at Massey Agricultural

College in which a "clean" marrow-stem kale crop gave sixty per cent greater green matter yield and eighty per cent greater dry matter yield than a "weedy" crop (Schwass 1957). Robinson (1956) has also shown the beneficial effect on yield of inter-row cultivation to suppress weeds. A high soil fertility level may also be a contributory factor, since the heavy concentration of stock carried in the winter of 1956 would be effective in supplying considerable nutrients in the form of dung and urine to the soil. The beneficial effect on yield of animal residues returned to a pasture has been dealt with by Sears et al. (1953). Partly counterbalancing the supply of nutrients to the present experimental area is the fact that green matter yields quoted in Table 1 were chiefly the means of yields obtained from thinning treatments at several levels of nitrogen manuring.

With the proviso that the results are only from one treatment and in one year, it appears as though marrow-stem growth was not affected by the severe poaching suffered by the soil prior to ploughing. Judging from the yield of soft turnips grown adjacent to the experimental area, this crop was not affected either (Nalson 1957). At present the response of other crops to "pre-poaching" is speculative.

The effect of thinning on the green and dry matter yields of the component parts was evident only in the case of lower leaf and upper stem. Both green and dry matter yields of the former increased with increasing severity of thinning. The effect of thinning on lower leaf is related to the observation made that the unthinned treatment gave tall, thin-stemmed plants with the leaves concentrated near the top whilst the 12" thinned

plants were thick-stemmed with the leaves growing fairly well down the stem. In the case of upper stem, thinning did not affect green matter yields but caused dry matter yields to decrease with increasing severity of thinning. This latter effect was the result of decreasing plant dry matter percentages with increasing severity of thinning.

Reference to figures 11 and 12 shows that in all three treatments throughout the sampling period, the green and dry matter yields of upper leaf remained relatively constant in comparison with the stem-component yields, which increased over the sampling period. Lower-leaf yields which were never very high soon declined to zero. It is therefore apparent that as the plants matured, the stem continued to develop, whilst the leafage retained on the crop did not increase proportionately, due in part at least to shedding of the lower leaves. Yields of lower stem frequently outyielded those of upper stem. This may be attributed to the nature of the stems as examination of cross-sections showed that the proportion of woody xylem was greatest in the lower stem. Green and dry matter yields of total leaf (see Tables V and VIII respectively) if graphically represented, would show a "curve" of initially decreasing yields, levelling off to a relative constancy over the sampling period.

In view of the above facts, the following may be deduced. In marrow-stem kale, total-leaf green and dry matter yields increase from germination to a maximum level. Since the leaf yields were in a declining phase at the start of the present sampling period, it would appear that the maximum level is reached before the age of approximately four months. The declining

phase is followed by one of relative constancy and this constant phase began between the ages of four to five months in the present trial and was still continuing when the trial ended.

The effect of leaf shedding probably plays a major part in these changes. Visual observations of the present trial suggest that leaf shedding begins shortly after marrow-stem kale growth covers the ground surface. Shade as a causal factor seems implicated but stage of maturity and other factors are also probably concerned as unshaded, isolated plants also shed lower leaves. Hypothetically, leaf yields reach a maximum level either just before the onset of shedding or, after the onset if leaf production more than compensates for leaf shedding. The declining phase results when leaf shedding exceeds leaf production and finally the relatively constant phase is when leaf production equals leaf shedding. A study of the following problems would give valuable information in interpreting variation in marrow-stem kale growth, particularly in view of the importance of leaf to the value of the crop:

(a) The causal factors initiating and governing the rate of leaf shedding.

(b) Stage of maturity at which (i) onset of leaf shedding begins, (ii) maximum level of leaf yields is attained, and (iii) onset of the declining phase and constant phase begin.

(c) The length of time during which the constant phase is maintained.

The relative growth rates of the three treatment types, as judged from the green and dry matter yield increments between the sampling dates were not constant, nor were they uniform

between the treatments over the sampling period. One observation from the growth curves (see figs. 11 and 12) is that the growth increments during the latter half of the sampling period were in general, greater than during the first half. This can probably be regarded as an expression of "compound interest", that is, as the plant grows in size and the photosynthetic tissue increases in area, so also does the rate of growth, at least during the initial stages of the plant's life. It was observed from the meteorological data (Appendix 1) that during the latter half of the experiment, rainfall increased and evaporation decreased. However, in the interpretation of the rate of growth of plants, many factors are involved. Watson (1952) has stated:

"The problem of accounting for variation of yield in terms of growth and development of the crop plant is obviously very complex, for ultimately it involves the effect of external factors on all the physiological processes of the plant, the interrelation between different processes, and their dependence on internal factors determined by the genetical constitution of the plant."

The finding that leaf percentages in the present trial were influenced by thinning is in agreement with results from Edin et al. (1933), Simola (1932), Fagan et al. (1943) and the Rothamsted Annual Reports (1932, 1933). These authors did not comment that the effect of thinning decreased with time as in the present trial, but this may have been because of a shorter sampling period or a fewer number of sampling dates. Consequently,

such an effect would be missed. They were also dealing with material of six to eight months of age, so that the crop may have passed the stage when such an effect was descernible.

The decrease in leaf percentages with time in all the treatments, observed in the current investigation, was in accordance with the results of Bünger et al. (1933), Edin et al. (1933), Robinson (1954) and the Rothamsted Annual Reports (1932, 1933). This decrease is attributable to the continued growth of the stem, whilst leafage did not increase proportionately, due in part at least to shedding of the lower leaves. This aspect, along with other factors affecting the leaf-stem relationship has already been discussed.

C H A P T E R IV

COMPOSITION

This section will be presented in three parts as follows:

(a) The experimental materials and methods used to determine the composition.

(b) The experimental results obtained.

(c) A discussion of the experimental results.

(a) Experimental Materials and Methods

Dry Matter Percentage

The experimental materials and methods employed to determine the dry matter percentages of the component parts of the three treatment types of marrow-stem kale have been already described (see pp.32-33).

Chemical Composition

The samples used to determine the dry matter percentages provided the material to determine the crude protein, crude fibre, ether extract, mineral matter and nitrogen-free extract percentages. The analyses were conducted on representative laboratory samples drawn from material from sampling dates, 11th January, 31st January, 20th February and 12th March.

Chemical analyses were conducted in duplicate according to the methods recommended by the Association of Official Agricultural Chemists (1952).

Since the number of analyses that can be done by one person is limited, the component-part samples of each treatment from the four blocks were bulked at each sampling date. In the subsequent analyses of variance (Snedecor 1956, pp.291 *et seqq.*), neither within-plot nor between-block variations could therefore be separately taken out.

Carotene estimations were conducted on samples taken from the lengths of sample rows reserved for the purpose (see fig. 2). Samples were taken on sampling dates, 31st January, 20th February and 12th March. One 6-foot sample was taken at random from each of the treatment plots within a block; this

was repeated in all four blocks and the corresponding treatment samples bulked. Each 6-foot sample consisted of paired 3-foot lengths taken from the middle of the guard lengths in the paired sample rows. For each treatment type therefore, a 24-foot sample was obtained. Each sample was then divided into the respective component parts, that is, upper leaf, lower leaf, upper stem and lower stem. From each of these parts, representative sub-samples were taken, sealed in plastic containers and removed to the freeze-drier. Representative 250-gram laboratory samples of each component part were freeze-dried.

To ensure representative sampling and to facilitate drying out, stem samples were sliced into thin cross-sections with a sharp knife before the laboratory sample was drawn. Laboratory samples of leaves were drawn from the whole leaves, which were then clipped with scissors into small pieces to aid the freeze-drying process.

After removal from the freeze-drier, the samples were ground in a laboratory mill, sealed in airtight glass jars and stored in darkness in deep freeze until the carotene determinations were conducted. These were conducted according to the method of Worker (1957) and the carotene contents expressed as micrograms per gram of dry matter.

(b) Experimental Results

The results will be presented in three parts as follows:

(i) Dry matter percentage.

(ii) Chemical composition - percentage basis.

(iii) Chemical composition - yield basis.

The presentation of results is similar to the previous section on yield and the abbreviations used are the same. Again, transformation of the percentage data for the composition into angles was not considered warranted, as the percentages did not vary widely.

(1) Dry Matter Percentage

The dry matter percentages, calculated for the individual summed component parts of each summed plot sample at each sampling date, are presented in tabular form in Appendix 9. The mean dry matter percentages for each summed component part, calculated from the total number of summed component-part samples taken from each treatment type of marrow-stem kale, at each sampling date, are presented graphically in figure 15.

To elucidate the relationship between the dry matter percentages from different treatments, individual analyses of variance were carried out on the summed component part samples at each sampling date. The results of these analyses are summarized in Table XV. The dry matter percentages obtained for lower leaf were not analysed beyond the third sampling date, as thereafter, particularly in the unthinned and 6" thinned marrow-stem kale, the plot samples had either no lower leaf, or yielded amounts too small to gain accurate evaluations of their dry matter percentages.

Comparison of the upper-leaf dry matter percentages from the three treatments during the sampling period showed that no one treatment gave consistently higher percentages than another. The treatment differences did not attain statistical significance at any of the sampling dates. Similar results to these were obtained with lower-leaf dry matter percentages. With upper stem, the dry matter percentages showed a tendency to decrease with increasing severity of thinning; treatment differences were significant at the third and fifth sampling

Table XV

Table XV

Results of the Analyses of Variance on the Dry Matter Percentages of the Component Parts of each Treatment Type of Marrow-stem Kale at each Sampling Date

Sampling Date (1957)	Treatment Means			S.E.s of Means	F Value[1]	F Result	Treatment Means			S.E.s of Means	F Value[1]	F Result
	Ut	St	Tt				Ut	St	Tt			
	Upper Leaf						Upper Stem					
Jan.11	11.5	13.2	12.2	±0.4	2.54	N.S.	8.5	8.1	7.9	±0.2	2.19	N.S.
Jan.21	13.2	14.1	14.2	±0.4	2.31	N.S.	9.8	9.0	8.7	±0.3	4.81	N.S.
Jan.31	13.5	13.9	14.2	±0.2	4.82	N.S.	9.4	10.7	8.5	±0.2	23.27	**[2]
Feb.10	14.7	14.5	14.3	±0.4	0.18	N.S.	10.5	9.2	9.4	±0.7	1.10	N.S.
Feb.20	15.0	13.8	14.4	±0.6	1.20	N.S.	11.6	9.5	9.3	±0.6	3.93	N.S.
Mar. 2	14.4	14.1	13.1	±0.4	2.37	N.S.	11.5	10.2	8.2	±0.7	6.09	*[3]
Mar.12	13.7	13.2	14.3	±0.5	1.26	N.S.	10.6	9.8	10.0	±0.6	0.45	N.S.
Mar.22	14.1	13.6	13.2	±0.7	0.48	N.S.	12.3	10.8	9.6	±0.8	2.82	N.S.
	Lower Leaf						Lower Stem					
Jan.11	10.7	10.4	9.6	±0.5	1.47	N.S.	11.6	11.5	10.0	±0.6	2.50	N.S.
Jan.21	11.7	11.6	10.2	±0.4	4.93	N.S.	12.2	12.0	11.0	±0.9	0.57	N.S.
Jan.31	11.7	11.2	11.4	±0.7	0.17	N.S.	12.4	13.2	11.9	±0.3	0.43	N.S.
Feb.10	12.6	11.3	12.3	±0.5	1.72	N.S.	13.5	12.1	10.6	±0.7	4.53	N.S.
Feb.20	13.8	14.4	12.4	±0.7	2.42	N.S.	13.8	11.3	13.7	±0.8	3.33	N.S.
Mar. 2	-	-	-	-	-	-	13.7	13.4	12.8	±1.1	1.66	N.S.
Mar.12	-	-	-	-	-	-	14.1	12.5	12.3	±1.1	0.77	N.S.
Mar.22	-	-	-	-	-	-	15.9	13.4	13.8	±0.9	2.12	N.S.

[1] F value required, .05(.01) = 5.14(10.92)

[2] d required, .05(.01) = .8(1.2)

[3] In addition, Regression *
Deviation N.S.

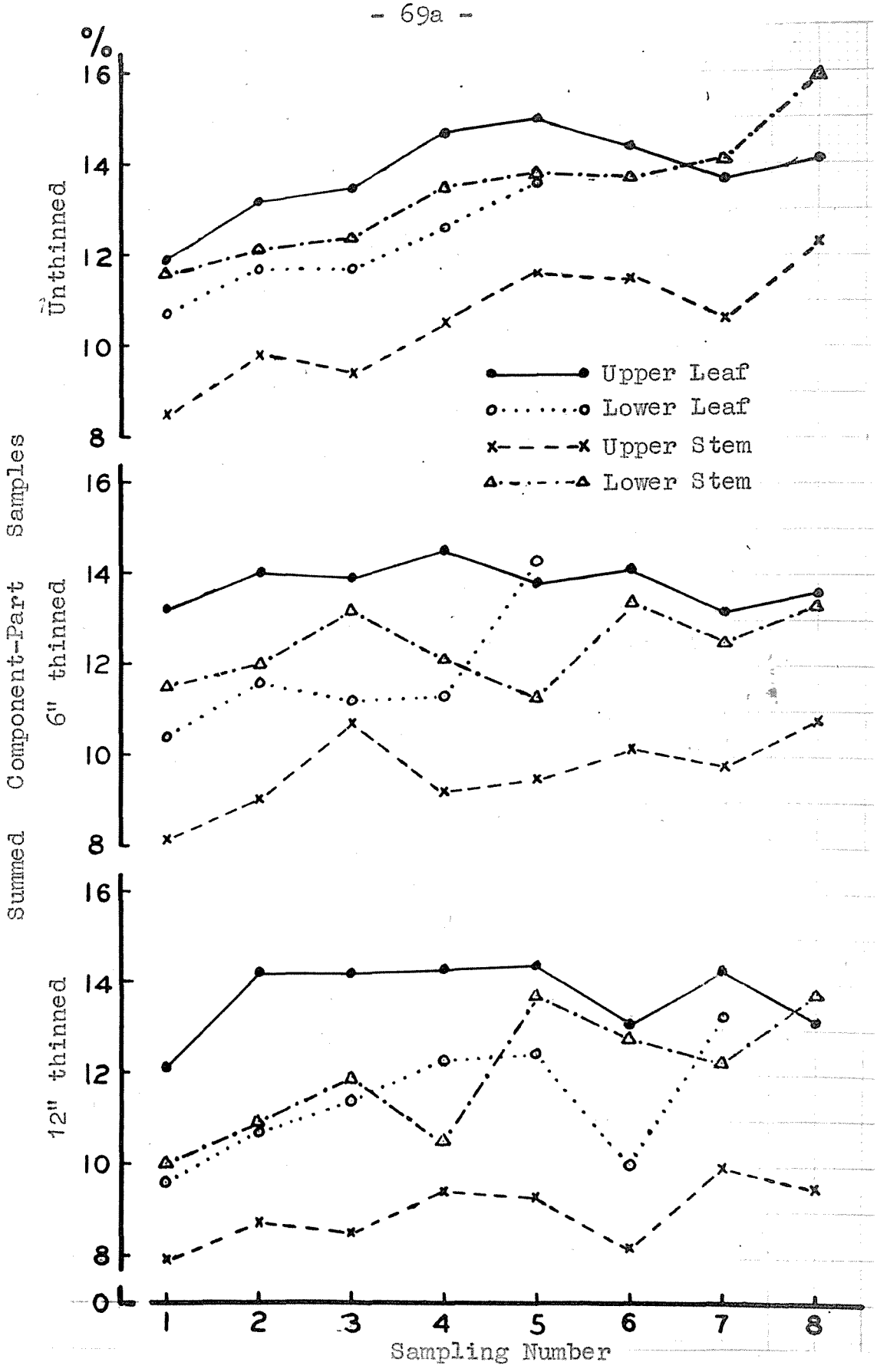


Figure 15

Mean Dry Matter Percentages for each Summed Component Part of the Three Treatments

dates. At the latter date, the treatment means also showed a significant linear regression — with non-significant deviation — of decreasing dry matter percentages with increasing severity of thinning. Lower-stem percentages showed a similar trend to those of upper stem, but the differences were not significant.

Further inspection of the data showed certain distinguishable trends in component-part dry matter percentages during the sampling period. In all treatments, and at the majority of the sampling dates in each treatment, the component-part percentages were in the descending order of upper leaf, lower ste lower leaf and upper stem respectively. Although the percentage levels of upper stem and lower stem fluctuated during the sampling period, a general trend of increasing dry matter percentages with time was evident. After the third sampling date, lower-leaf dry matter percentages showed great variation.

To establish the relationship between the component-part dry matter percentages from the three treatments over the sampling period, analyses of variance were carried out on these percentages over all sampling dates. The split-plot type of experimental design was used. The analyses are set out in Appendix 10 and the relevant details of these analyses presented in Table XVI. Lower-leaf dry matter percentages were not analysed for reasons already given.

The results showed that differences between treatment means for upper leaf and lower stem did not attain significance, but those for lower leaf and upper stem differed significantly and further showed significant linear regressions — with non-significant deviations — of decreasing dry matter

Table XVI

Results of Analyses of Variance on the Dry Matter Percentages of the Component Parts of the Treatment Types of Marrow-stem Kale over all Sampling Dates

Sample / Treatment	Upper Leaf	Lower Leaf	Upper Stem	Lower Stem
	(a) Treatment Means			
Unthinned	13.8	12.1	10.5	13.4
6" thinned	13.8	11.8	9.7	12.4
12" thinned	13.8	11.2	8.8	12.0
S.E.s of means	±0.1	±0.2	±0.3	±0.4
F test result	N.S.	*	*	N.S.
Regression	-	*	**	-
Deviation	-	N.S.	N.S.	-
Date (1957)	(b) Date Means			
Jan. 11	12.4	10.2	8.2	11.0
Jan. 21	13.8	11.2	9.2	11.7
Jan. 31	13.9	11.4	9.5	12.5
Feb. 10	14.5	12.1	9.7	12.1
Feb. 20	14.4	13.5	10.1	12.9
Mar. 2	13.9	-	10.0	13.3
Mar. 12	13.7	-	10.1	13.0
Mar. 22	13.6	-	10.9	14.4
S.E.s of means	±0.3	±0.4	±0.3	±0.5
F test result	**	**	**	**
Regression	-	**	**	**
Deviation	-	N.S.	N.S.	N.S.
d reqd. .05(.01)	0.8(1.0)	-	-	-

percentages with increasing severity of thinning. The between-date means differed significantly in all four components; lower leaf, upper stem and lower stem also showed significant linear regressions — with non-significant deviations — of increasing dry matter percentages with time.

The average dry matter percentages for each treatment type of marrow-stem kale taken as a whole, were calculated at each sampling date. The dry matter weights of the plot (whole plant) samples for each treatment from the four blocks were summed at each sampling date and the resulting totals combined with their corresponding green-matter weight totals to give the required dry matter percentages. These are tabulated in Table XVII.

Between treatments, a trend of decreasing dry matter percentages with increasing severity of thinning was apparent, though it was not wholly consistent for all sampling dates. Between dates, a trend of increasing dry matter percentages with time was evident in the unthinned treatment, but in the other treatments, the percentages did not vary much from beginning to end of the sampling period. An analysis of variance showed that the between-treatment and between-date means respectively, did not differ significantly.

Table XVII

The Average Dry Matter Percentages for each Treatment Type of Marrow-stem Kale taken as a Whole, at each Sampling Date

Treatment \ Date	Jan. 11	Jan. 21	Jan. 31	Feb. 10	Feb. 20	Mar. 2	Mar. 12	Mar. 22	Means	S.E. of Means
Unthinned	10.7	11.8	11.8	12.7	13.2	12.8	12.5	14.1	12.5	
6" thinned	11.2	11.9	12.2	11.8	11.3	12.4	11.5	12.4	11.8	±0.6
12" thinned	10.3	11.5	11.6	11.3	12.4	11.2	12.0	11.9	11.5	
Means	10.7	11.7	11.9	11.9	12.3	12.1	12.0	12.8		
S.E. of Means	±1.0									

Table XVIII

Table XVIII

Chemical Composition of the Component Parts and Whole Plants of the Three Treatment Types of Marrow-Stem Kale (stated as % - on a moisture-free basis)

Component Part	Sampling Date (1957)	Crude Protein			Crude Fibre			Ether Extract			Mineral Matter			Nitrogen-free Extract		
		Treatment			Treatment			Treatment			Treatment			Treatment		
		Ut	St	Tt	Ut	St	Tt	Ut	St	Tt	Ut	St	Tt	Ut	St	Tt
Upper Leaf	Jan.11	18.3	17.7	18.2	15.0	17.7	16.3	3.9	3.3	3.4	15.6	16.5	15.6	47.2	44.8	46.7
	Jan.31	16.4	16.7	17.0	13.2	12.1	13.7	3.9	3.2	3.4	14.9	14.3	14.7	51.5	53.8	51.3
	Feb.20	17.7	17.9	16.5	11.6	11.1	12.4	3.2	3.5	2.7	15.2	14.8	14.3	52.3	52.7	54.1
	Mar.12	15.9	16.4	16.2	12.9	12.1	11.8	3.7	3.3	3.9	14.6	15.0	15.9	52.9	53.2	52.2
Lower Leaf	Jan.11	9.5	10.2	10.0	18.2	16.3	17.0	4.2	3.9	4.4	16.1	17.0	15.7	52.0	52.7	53.0
	Jan.31	9.2	10.0	10.0	14.2	13.0	15.9	4.0	3.4	4.2	18.5	16.6	18.0	54.1	57.0	51.9
	Feb.20	10.6	10.1	8.8	16.2	17.0	16.7	3.8	3.6	3.3	19.0	21.5	20.9	50.4	47.9	50.3
	Mar.12	-	-	8.2	-	-	15.7	-	-	3.9	-	-	19.6	-	-	52.7
Upper Stem	Jan.11	12.3	11.8	13.7	20.0	20.5	19.0	1.3	1.4	1.3	13.7	13.8	13.7	52.7	52.5	51.3
	Jan.31	9.8	11.0	11.0	21.3	22.5	20.0	1.1	1.0	1.1	11.6	10.7	12.2	56.2	54.8	55.7
	Feb.20	8.9	10.6	11.9	23.9	22.3	21.9	0.9	0.9	0.9	11.9	13.2	13.3	54.4	53.0	51.0
	Mar.12	8.0	9.8	10.4	22.8	20.3	19.5	1.4	1.9	1.4	14.3	14.4	14.4	53.5	53.6	54.4
Lower Stem	Jan.11	7.6	8.3	7.0	32.1	32.5	30.3	1.1	1.2	1.4	11.1	11.1	12.6	48.1	47.0	48.7
	Jan.31	6.6	7.3	8.8	32.9	30.5	29.0	0.4	0.3	0.6	11.9	9.4	10.7	48.2	52.6	50.9
	Feb.20	6.8	6.7	7.3	31.1	31.8	32.5	0.9	0.9	0.9	11.7	11.9	11.5	49.6	48.8	47.8
	Mar.12	5.5	7.0	7.4	32.0	29.6	29.1	0.6	0.5	0.7	11.8	11.3	10.2	50.2	51.6	52.6
Whole Plant	Jan.11	12.7	12.7	13.3	22.5	23.3	20.9	2.3	2.3	2.5	13.5	14.1	14.4	48.9	47.6	48.9
	Jan.31	10.8	11.4	12.5	23.0	22.2	20.9	1.8	1.5	1.9	12.9	11.4	12.7	51.5	53.5	52.0
	Feb.20	10.5	11.1	11.3	23.4	22.9	23.6	1.5	1.7	1.5	12.7	13.2	12.9	51.9	51.1	50.7
	Mar.12	9.1	10.3	11.1	24.0	22.1	20.8	1.7	1.7	1.7	13.4	13.2	13.3	51.8	52.7	53.1

(ii) Chemical Composition - Percentage Basis

The percentages of crude protein, crude fibre, ether extract, mineral matter and nitrogen-free extract, determined for the component parts, and for the whole plants by calculation, of the three treatment types of marrow-stem kale at the first, third, fifth and seventh sampling dates respectively, are set out in tabular form in Table XVIII.

To elucidate the relationship between the percentages of chemical constituents from the different treatments over the sampling period, analyses of variance were carried out on the percentages of each constituent of each component part, and of the whole plant, over all sampling dates. The relevant details of these analyses are set out in Tables XIX-XXIV.

Crude Protein

Between the treatment means, only small differences, reflected in the non-significant results from the analyses of variance, were apparent in the case of upper leaf, lower leaf and lower stem. The means for upper stem differed significantly and further showed a significant linear regression — with non-significant deviation — of increasing crude protein percentages with increasing severity of thinning. Between-date means showed significant differences in the case of upper leaf and upper stem. The latter in addition showed a significant linear regression — with non-significant deviation — of decreasing crude protein percentages with time.

Reference to Table XVIII shows that the crude protein percentages of the component parts in each treatment were in the descending order of upper leaf, upper stem, lower leaf and lower

stem respectively at the majority of the sampling dates.

Table XIX

Results of Analyses of Variance on Crude Protein Percentages of the Component Parts of the Three Treatment Types of Marrow-stem Kale over all Sampling Dates

Sample / Treatment	Upper Leaf	Lower Leaf	Upper Stem	Lower Stem
	(a) Treatment Means			
Unthinned	17.1	9.8	9.8	6.6
6" thinned	17.2	10.1	10.8	7.3
12" thinned	17.0	9.6	11.8	7.6
S.E.s of means	±0.3	±0.4	±0.3	±0.4
F test result	N.S.	N.S.	*	N.S.
Regression	-	-	**	-
Deviation	-	-	N.S.	-
Date (1957)	(b) Date Means			
Jan. 11	18.1	9.9	12.6	7.6
Jan. 31	16.7	9.7	10.6	7.6
Feb. 20	17.4	9.8	10.5	6.9
Mar. 12	16.2	-	9.4	6.6
S.E.s of means	±0.3	±0.4	±0.4	±0.4
F test result	*	N.S.	**	N.S.
Regression	-	-	**	-
Deviation	-	-	N.S.	-
d reqd. .05	1.0	-	-	-

Crude Fibre

Table XX

Results of Analyses of Variance on Crude Fibre Percentages of the Component Parts of the Three Treatment Types of Marrow-stem Kale over all Sampling Dates

Sample / Treatment	Upper Leaf	Lower Leaf	Upper Stem	Lower Stem
	(a) Treatment Means			
Unthinned	13.2	16.2	22.0	32.0
6" thinned	13.3	15.4	21.4	31.1
12" thinned	13.6	16.5	20.1	30.2
S.E.s of means	±0.5	±0.6	±0.5	±0.6
F test result	N.S.	N.S.	N.S.	N.S.
Date (1957)	(b) Date Means			
Jan. 11	16.3	17.2	19.8	31.6
Jan. 31	13.0	14.4	21.3	30.8
Feb. 20	11.7	16.6	22.7	31.8
Mar. 12	12.3	-	20.9	30.2
S.E.s of means	±0.6	±0.6	±0.5	±0.7
F test result	**	N.S.	*	N.S.
d reqd. .05(.01)	2.0(3.1)	-	1.8	-

Within each component part, the treatment means for crude fibre percentage did not differ greatly and in no case were the differences sufficiently large to attain statistical significance. Between-date means differed significantly

in the upper-leaf and upper-stem components. Respective t-tests demonstrated that the mean crude fibre percentage at the first sampling date was significantly greater than the means at the other sampling dates in the case of upper leaf and significantly less in the case of upper stem.

In the crude fibre percentages of the component parts in each treatment, lower stem was highest throughout the sampling period; upper stem was next, followed by lower leaf and finally upper leaf. In general therefore, the order of crude fibre was the reverse of that found with crude protein percentages. The gap between leaf and stem was very marked. Lower stem frequently had crude fibre percentages in the region of thirty per cent, whilst upper leaf percentages were often between ten and fifteen per cent.

Ether Extract

There were extremely small differences between the treatment means in all the component parts and in no case were the differences statistically significant. The between-date means showed significant differences in both stem components, but no significant differences in both leaf components.

Reference to the data indicated that the component part ether extract percentages in each treatment type of marrow-stem kale were in the descending order of lower leaf, upper leaf, upper stem and lower stem respectively.

Table XXI

Results of Analyses of Variance on Ether Extract Percentages of the Component Parts of the Three Treatment Types of Marrow-stem Kale over all Sampling Dates

Sample / Treatment	Upper Leaf	Lower Leaf	Upper Stem	Lower Stem
	(a) Treatment Means			
Unthinned	3.7	4.0	1.2	0.8
6" thinned	3.3	3.6	1.3	0.7
12" thinned	3.4	4.0	1.2	0.9
S.E.s of means	±0.2	±0.2	±0.1	±0.1
F test result	N.S.	N.S.	N.S.	N.S.
Date (1957)	(b) Date Means			
Jan. 11	3.5	4.2	1.3	1.2
Jan. 31	3.5	3.9	1.1	0.4
Feb. 20	3.1	3.6	0.9	0.9
Mar. 12	3.6	-	1.6	0.6
S.E.s of means	±0.2	±0.2	±0.1	±0.1
F test result	N.S.	N.S.	**	**
d reqd. .05(.01)	-	-	0.3(0.4)	0.2(0.3)

Mineral Matter

Between the treatment means, only small differences, reflected in the non-significant results from the analyses of variance, were apparent in all the component parts. Between-date

means differed significantly for the lower-leaf and upper-stem components. No general trends with time were apparent in any of the component parts except lower leaf, in which the date means showed a significant linear regression -- with non-significant deviation -- of increasing mineral matter percentages with time.

Table XXII

Results of Analyses of Variance on Mineral Matter Percentages of the Component Parts of the Three Treatment Types of Marrow-stem Kale over all Sampling Dates

Sample / Treatment	Upper Leaf	Lower Leaf	Upper Stem	Lower Stem
	(a) Treatment Means			
Unthinned	15.1	17.9	12.9	11.6
6" thinned	15.2	18.4	13.0	10.9
12" thinned	15.1	18.2	13.4	11.3
S.E.s of means	±0.3	±0.6	±0.3	±0.5
F test result	N.S.	N.S.	N.S.	N.S.
Date (1957)	(b) Date Means			
Jan. 11	15.9	16.3	13.7	11.6
Jan. 31	14.6	17.7	11.5	10.7
Feb. 20	14.8	20.5	12.8	11.7
Mar. 12	15.2	-	14.4	11.1
S.E.s of means	±0.3	±0.6	±0.3	±0.5
F test result	N.S.	*	**	N.S.
Regression	-	**	-	-
Deviation	-	N.S.	-	-
d reqd. .05(.01)	-	-	0.7(1.2)	-

The component-part percentages followed a pattern similar to that of the crude protein percentages, except that upper leaf and lower leaf components had changed positions. Lower leaf had the highest mineral matter percentage, followed by upper leaf, upper stem and lastly, lower stem.

Nitrogen-free Extract

Table XXIII

Results of Analyses of Variance on Nitrogen-free Extract Percentages of the Component Parts of the Three Treatment Types of Marrow-stem Kale over all Sampling Dates

Samples / Treatment	Upper Leaf	Lower Leaf	Upper Stem	Lower Stem
	(a) Treatment Means			
Unthinned	51.0	52.2	54.2	49.0
6" thinned	51.1	52.5	53.5	50.0
12" thinned	51.1	51.7	53.8	50.0
S.E.s of means	±0.6	±1.2	±0.4	±0.7
Date (1957)	(b) Date Means			
Jan. 11	46.2	52.6	52.5	47.9
Jan. 31	52.2	54.3	55.6	50.6
Feb. 10	53.0	49.5	53.1	48.7
Mar. 12	52.8	-	53.8	51.5
S.E.s of means	±0.7	±1.2	±0.4	±0.9
F test result	**	N.S.	*	N.S.
d reqd, .05(.01)	2.5(3.8)	-	1.5	-

Within each component part, the treatment means for nitrogen-free extract percentage did not differ greatly and in no case were the differences sufficiently large to attain statistical significance. Between-date means differed significantly for the upper leaf and upper stem components. The variation between percentages during the sampling period was not consistent in all component parts and consequently, no general trends were evident.

Throughout the sampling period, variation between the nitrogen-free extract percentage levels of the component parts in all treatments was greater than that existing in the other chemical constituentslevels. However, reference to the data showed a general pattern of nitrogen-free extract percentages in the descending order of upper stem, lower leaf, upper leaf and lower stem respectively.

Chemical Composition of Whole Plant

The treatment-mean percentages in each of the chemical constituents, crude fibre, ether extract, mineral matter and nitrogen-free extract did not differ greatly and in each case, the differences were non-significant. With crude protein, however, the treatment means differed significantly and also showed a significant linear regression — with non-significant deviation — of increasing crude protein percentages with increasing severity of thinning. The between-date means differed significantly with each chemical constituent except crude fibre. The crude protein date means further showed a significant linear regression — with non-significant deviation — of decreasing

Table XXIV

Results of Analyses of Variance on the Percentage Composition of the Plants taken as a Whole of the Three Treatment Types of Marrow-stem Kale over all Sampling Dates

Chemical Constituent / Treatment	Crude Protein	Crude Fibre	Ether Extract	Mineral Matter	Nitrogen-free Extract
	(a) Treatment Means				
Unthinned	10.8	23.2	1.8	13.1	51.0
6" thinned	11.4	22.6	1.8	13.0	51.2
12" thinned	12.1	21.6	1.9	13.3	51.2
S.E.s of means	±0.2	±0.4	±0.1	±0.3	±0.5
F test result	**	N.S.	N.S.	N.S.	N.S.
Regression	**	-	-	-	-
Deviation	N.S.	-	-	-	-
Date (1957)	(b) Date Means				
Jan. 11	12.9	22.1	2.4	14.0	48.5
Jan. 31	12.6	22.0	1.7	12.3	52.3
Feb. 20	11.0	23.3	1.6	12.9	51.2
Mar. 12	10.2	22.3	1.7	13.3	52.5
S.E.s of means	±0.2	±0.5	±0.1	±0.3	±0.5
F test result	**	N.S.	**	*	**
Regression	**	-	-	-	-
Deviation	N.S.	-	-	-	-
d reqd. .05(.01)	-	-	0.2(0.4)	1.0	1.6(2.4)

percentages with time. With ether extract and mineral matter percentages, respective t-tests demonstrated that the date means at the first sampling date were significantly greater than those at later sampling dates, for both chemical constituents. In the case of nitrogen-free extract, a t-test indicated that the date mean at the first sampling date was significantly less than the means at later sampling dates.

Table XXV

Table XXV

Chemical Constituent Yields of the Component Parts and Whole Plants
of the Three Treatment Types of Marrow-stem Kale
(stated in lbs - 36-foot sample basis)

Component Part	Sampling Date (1957)	Crude Protein			Crude Fibre			Ether Extract			Mineral Matter			Nitrogen-free Extract		
		Treatment			Treatment			Treatment			Treatment			Treatment		
		Ut	St	Tt	Ut	St	Tt	Ut	St	Tt	Ut	St	Tt	Ut	St	Tt
Upper Leaf	Jan.11	3.78	3.93	4.20	3.09	3.93	3.78	0.81	0.75	0.78	3.21	3.66	3.60	9.75	9.96	10.77
	Jan.31	3.85	3.88	4.45	3.10	2.81	3.59	0.92	0.74	0.89	3.50	3.32	3.85	12.09	12.50	13.43
	Feb.20	4.14	3.74	4.03	2.71	2.32	3.03	0.75	0.73	0.66	3.56	3.09	3.49	12.24	11.01	13.20
	Mar.12	4.06	4.02	4.55	3.29	2.96	3.31	0.94	0.81	1.09	3.73	3.67	4.46	13.51	13.03	14.65
Lower Leaf	Jan.11	0.18	0.42	0.54	0.36	0.69	0.90	0.09	0.18	0.24	0.30	0.72	0.84	0.99	2.22	2.82
	Jan.31	0.08	0.08	0.13	0.12	0.10	0.20	0.04	0.03	0.05	0.16	0.13	0.23	0.48	0.45	0.65
	Feb.20	0.03	0.06	0.05	0.05	0.10	0.09	0.01	0.02	0.02	0.05	0.12	0.11	0.14	0.27	0.27
	Mar.12	-	-	0.01	-	-	0.04	-	-	0.01	-	-	0.05	-	-	0.12
Upper Stem	Jan.11	1.68	1.26	1.38	2.71	2.19	1.92	0.18	0.15	0.12	1.86	1.47	1.38	7.17	5.58	5.29
	Jan.31	1.71	2.04	1.67	3.71	4.17	3.04	0.19	0.19	0.17	2.02	1.98	1.86	9.79	10.15	8.47
	Feb.20	2.49	2.30	2.40	6.70	4.84	4.42	0.25	0.20	0.18	3.34	2.87	2.69	15.25	11.51	10.50
	Mar.12	2.58	2.93	2.90	7.35	6.07	5.43	0.45	0.57	0.39	4.61	4.31	4.01	17.24	16.03	15.15
Lower Stem	Jan.11	1.56	1.68	1.11	6.54	6.51	4.77	0.24	0.21	0.21	2.25	2.22	1.98	9.78	9.42	7.65
	Jan.31	1.78	2.10	2.25	8.85	8.77	7.42	0.11	0.09	0.15	3.20	2.70	2.74	12.97	15.13	13.02
	Feb.20	2.33	1.98	2.55	10.67	9.39	11.37	0.31	0.27	0.31	4.01	3.52	4.02	17.01	14.42	16.72
	Mar.12	2.18	2.79	2.58	12.70	11.80	10.13	0.24	0.20	0.24	4.68	4.50	3.55	19.92	20.56	18.30
Whole Plant	Jan.11	7.17	7.28	7.22	12.68	13.31	11.34	1.29	1.29	1.37	7.65	8.06	7.79	27.68	27.14	26.50
	Jan.31	7.41	8.10	8.50	15.78	15.83	14.25	1.26	1.05	1.26	8.88	8.13	8.68	35.33	38.23	35.57
	Feb.20	8.99	8.08	9.03	20.13	16.65	18.91	1.32	1.22	1.17	10.96	9.60	10.31	44.64	37.21	40.69
	Mar.12	8.82	9.74	10.05	23.34	20.83	18.91	1.63	1.58	1.73	13.02	12.48	12.07	50.67	49.62	48.22

(iii) Chemical Composition - Yield Basis

The yields of crude protein, crude fibre, ether extract, mineral matter and nitrogen-free extract, of each summed component-part sample, and of the whole plants, of each treatment type of marrow-stem kale, were calculated at each sampling date and the results presented in Table XXV. The yields from the first sampling date, when two samples per plot were taken, were adjusted to a three samples per plot basis, in order to be directly comparable with the yields from the other sampling dates.

To define the relationship between the yields of chemical constituents from the different treatments over the sampling period, analyses of variance were carried out on the yields of each constituent of each component part, and of the whole plant, over all sampling dates. The relevant details of these analyses are set out in Tables XXVI-XXXI.

Crude Protein

Treatment appeared to exercise little effect on the protein yield levels of all the component parts except upper leaf. In the latter, the treatment means differed significantly and a t-test demonstrated that the mean yield from the 12" thinning treatment was significantly greater than the mean yields from the other two treatments. Date means differed significantly in all component parts except upper leaf. In addition, the means for upper stem and lower stem showed significant linear regressions — with non-significant deviations — of increasing crude

protein yields with time, whilst those of lower leaf showed a significant regression — with non-significant deviation — of decreasing yields with time.

In all treatments throughout the sampling period, upper leaf had the highest yield of crude protein and lower leaf the lowest. Between these two components lay upper stem and lower stem with fairly similar yield levels.

Table XXVI

Results of Analyses of Variance on Crude Protein Yields of the Component Parts of the Three Treatment Types of Marrow-stem Kale over all Sampling Dates

Sample / Treatment	Upper Leaf	Lower Leaf	Upper Stem	Lower Stem
	(a) Treatment Means			
Unthinned	3.96	0.10	2.12	1.96
6" thinned	3.89	0.19	2.14	2.14
12" thinned	4.31	0.24	2.09	2.12
S.E.s of means	±0.1	±0.1	±0.1	±0.2
F test result	*	N.S.	N.S.	N.S.
d reqd. .05	0.30	-	-	-
Date (1957)	(b) Date Means			
Jan. 11	3.97	0.38	1.44	1.45
Jan. 31	4.06	0.10	1.81	2.04
Feb. 20	3.97	0.05	2.40	2.29
Mar. 12	4.21	-	2.80	2.52
S.E.s of means	±0.1	±0.1	±0.1	±0.2
F test result	N.S.	**	**	**
Regression	-	**	**	**
Deviation	-	N.S.	N.S.	N.S.

Crude Fibre

Table XXVII

Results of Analyses of Variance on Crude Fibre Yields of the Component Parts of the Three Treatment Types of Marrow-stem Kale over all Sampling Dates

Sample / Treatment	Upper Leaf	Lower Leaf	Upper Stem	Lower Stem
	(a) Treatment Means			
Unthinned	3.05	0.18	5.12	9.69
6" thinned	3.01	0.30	4.32	9.12
12" thinned	3.43	0.40	3.70	8.42
S.E.s of means	±0.2	±0.1	±0.3	±0.5
F test result	N.S.	N.S.	*	N.S.
Regression	-	-	**	-
Deviation	-	-	N.S.	-
Date (1957)	(b) Date Means			
Jan. 11	3.60	0.65	2.27	5.94
Jan. 31	3.17	0.14	3.64	8.35
Feb. 20	2.69	0.08	5.32	10.48
Mar. 12	3.19	-	6.28	11.54
S.E.s of means	±0.2	±0.1	±0.3	±0.6
F test result	N.S.	*	**	**
Regression	-	**	**	**
Deviation	-	N.S.	N.S.	N.S.

Of the component parts, only upper-stem treatment means differed significantly. This part also showed a significant linear regression — with non-significant deviation — of

decreasing crude fibre yields with increasing severity of thinning. A similar trend though not significant was evident in the lower stem component. Date means differed significantly in all component parts except upper leaf. The means for lower leaf further showed a significant linear regression — with non-significant deviation — of decreasing crude fibre yields with time, whilst those of upper stem and lower stem showed significant linear regressions — with non-significant deviations — of increasing yields with time. The situation with crude fibre yields was therefore similar to that existing with crude protein yields.

Component-part crude fibre yields of the three treatments were in the descending order of lower stem, upper stem, upper leaf and lower leaf respectively throughout the sampling period. Lower-stem yields were much greater than those of the other components and provided approximately half of the total crude fibre yield in all three treatments at each sampling date. Upper stem and upper leaf components which had initially fairly similar crude fibre yields soon diverged, as the yields of upper stem increased over the sampling period, whilst those of upper leaf remained relatively stationary. This occurred in all three treatments.

Ether Extract

Treatment means did not differ significantly in any of the component parts. However, date means differed significantly for both upper-stem and lower-stem components. The variation between the means of the latter components was not consistent and

consequently no general trends were evident.

In comparison with yields of the other chemical constituents, ether extract yields of the component parts of the treatment types of marrow-stem kale were low. In all treatments, upper leaf had the highest yield and lower leaf the lowest; between these two lay upper stem and lower stem with fairly similar yield levels.

Table XXVIII

Results of Analyses of Variance on Ether Extract Yields of the Component Parts of the Three Treatment Types of Marrow-stem Kale over all Sampling Dates

Sample / Treatment	Upper Leaf	Lower Leaf	Upper Stem	Lower Stem
	(a) Treatment Means			
Unthinned	0.86	0.05	0.27	0.23
6" thinned	0.78	0.08	0.28	0.20
12" thinned	0.86	0.10	0.22	0.23
S.E.s of means	±0.1	±0.03	±0.02	±0.02
F test result	N.S.	N.S.	N.S.	N.S.
Date (1957)	(b) Date Means			
Jan. 11	0.78	0.17	0.15	0.23
Jan. 31	0.85	0.04	0.18	0.12
Feb. 20	0.71	0.02	0.21	0.30
Mar. 12	0.95	-	0.47	0.23
S.E.s of means	±0.1	±0.03	±0.03	±0.02
F test result	N.S.	N.S.	**	**
d reqd, .05(.01)	-	-	.09(.14)	.04(.07)

Mineral Matter

Table XXIX

Results of Analyses of Variance on Mineral Matter Yields of the Component Parts of the Three Treatment Types of Marrow-stem Kale over all Sampling Dates

Sample / Treatment	Upper Leaf	Lower Leaf	Upper Stem	Lower Stem
	(a) Treatment Means			
Unthinned	3.50	0.17	2.96	3.54
6" thinned	3.44	0.32	2.66	3.24
12" thinned	3.85	0.39	2.49	3.07
S.E.s of means	±0.1	±0.1	±0.1	±0.2
F test result	N.S.	N.S.	**	N.S.
Regression	-	-	**	-
Deviation	-	-	N.S.	-
Date (1957)	(b) Date Means			
Jan. 11	3.49	0.61	1.57	2.15
Jan. 31	3.56	0.17	1.95	2.88
Feb. 20	3.38	0.09	2.97	3.85
Mar. 12	3.95	-	4.31	4.24
S.E.s of means	±0.1	±0.1	±0.1	±0.2
F test result	N.S.	*	**	**
Regression	-	*	-	**
Deviation	-	N.S.	-	N.S.
d reqd. .05(.01)	-	-	.28(.41)	-

The between-treatment means did not differ significantly in any of the component parts except upper leaf. The means of

this part further showed a significant linear regression — with non-significant deviation — of decreasing mineral matter yields with increasing severity of thinning. A similar trend, though non-significant, was evident in the lower stem component. Again, with the exception of upper leaf, the date means differed significantly for all component parts. Lower-leaf means showed a significant linear regression — with non-significant deviation — of decreasing mineral matter yields with increasing time, whilst those of lower stem showed a significant linear regression, with non-significant deviation, of increasing yields with time.

Mineral matter yields of the component parts of the treatment types of marrow-stem kale were initially in the descending order of upper leaf, lower stem, upper stem and lower leaf respectively. However, as the stem-component mineral matter yields increased with time, whilst those of upper leaf remained relatively constant, the order in descending levels, at the final sampling date, was lower stem, upper stem, upper leaf and lower leaf respectively.

Nitrogen-free Extract

Treatment means differed significantly in component parts upper leaf and upper stem. With the former, a t-test showed that the mean from the 12" thinning treatment was significantly greater than the mean from the other two treatments. Upper stem means showed a significant linear regression - with non-significant deviation - of decreasing nitrogen-free extract yields with increasing severity of thinning. Between-date means

Table XXX

Results of Analyses of Variance on Nitrogen-free Extract Yields of the Component Parts of the Three Treatment Types of Marrow-stem Kale over all Sampling Dates

Sample / Treatment	Upper Leaf	Lower Leaf	Upper Stem	Lower Stem
	(a) Treatment Means			
Unthinned	11.90	0.54	12.36	14.92
6" thinned	11.63	0.98	10.82	14.88
12" thinned	13.01	1.25	9.84	13.92
S.E.s of means	±0.2	±0.3	±0.5	±0.6
F test result	**	N.S.	*	N.S.
Regression	-	-	**	-
Deviation	-	-	N.S.	-
d reqd, .05(.01)	.71(1.08)	-	-	-
Date (1957)	(b) Date Means			
Jan. 11	10.16	2.01	6.00	8.95
Jan. 31	12.67	0.53	9.47	13.71
Feb. 20	12.15	0.23	12.42	16.05
Mar. 12	13.73	-	16.14	19.59
S.E.s of means	±0.2	±0.3	±0.6	±0.7
F test result	**	*	**	**
Regression	-	*	**	**
Deviation	-	N.S.	N.S.	N.S.
d reqd, .05(.01)	.82(1.25)	-	-	-

showed significant differences in all component parts. The means of both stem components also showed significant linear regressions — with non-significant deviations — of increasing nitrogen-free extract yields with time. On the other hand, lower-leaf means showed a significant linear regression — with non-significant deviation — of decreasing yields with time.

In each treatment type of marrow-stem kale, nitrogen-free extract yield levels were initially in the descending order of upper leaf, lower stem, upper stem and lower leaf respectively. However, stem-component yields increased with time whilst the yields of upper leaf remained relatively constant; consequently, by the end of the sampling period, the descending order became lower stem, upper stem, upper leaf and lower leaf respectively. Lower-stem yields were always considerably higher than upper stem yields.

Yields of Chemical Constituents of Whole Plants

The differences between treatment-mean yields in each of the chemical constituents were not sufficiently large to attain statistical significance. Contrary to this, between-date means differed significantly in all chemical constituents. In addition, with the exception of ether extract, all the chemical constituents showed significant linear regressions — with non-significant deviations — of increasing yields with time.

Table XXXI

Results of Analyses of Variance on the Chemical-Constituent Yields of the Plants taken as a Whole of the Three Treatment Types of Marrow-stem Kale over all Sampling Dates

Chemical Constituent / Treatment	Crude Protein	Crude Fibre	Ether Extract	Mineral Matter	Nitrogen-free Extract
	(a) Treatment Means				
Unthinned	8.10	17.98	1.38	10.13	39.58
6" thinned	8.30	16.66	1.29	9.57	38.05
12" thinned	8.70	15.85	1.38	9.71	37.75
S.E.s of means	±0.2	±0.7	±0.1	±0.2	±1.1
F test result	N.S.	N.S.	N.S.	N.S.	N.S.
Date (1957)	(b) Date Means				
Jan. 11	7.22	12.44	1.32	7.83	27.11
Jan. 31	8.00	15.29	1.19	8.56	36.38
Feb. 20	8.70	18.56	1.24	10.29	40.85
Mar. 12	9.54	21.03	1.65	12.52	49.50
S.E.s of means	±0.3	±0.8	±0.1	±0.2	±1.3
F test result	**	**	**	**	**
Regression	**	**	-	**	**
Deviation	N.S.	N.S.	-	N.S.	N.S.
d reqd, .05(.01)	-	-	.20(.30)	-	-

Carotene

The carotene contents determined for the component parts of the three treatment types of marrow-stem kale, at the third, fifth and seventh sampling dates respectively, are

presented in Table XXXII. The carotene contents of each treatment type taken as a whole were calculated from relevant data and are also presented in Table XXXII.

Table XXXII

Carotene Contents of Component Parts and Whole Plants of each Treatment Type of Marrow-stem Kale at each Sampling Date

(µg per gm. dry matter - moisture-free basis)

Component Part	Date 1957	Treatment		
		Unthinned	6" thinned	12" thinned
Upper Leaf	Jan.31	161	287	156
	Feb.20	137	176	124
	Mar.12	225	177	201
Lower Leaf	Jan.31	153	232	200
	Feb.20	-	-	-
	Mar.12	-	-	-
Upper Stem	Jan.31	6.8	4.0	6.4
	Feb.20	5.9	4.7	3.1
	Mar.12	10.2	5.2	6.8
Lower Stem	Jan.31	3.8	2.0	2.4
	Feb.20	5.7	3.5	2.4
	Mar.12	5.2	3.7	3.0
Whole Plant	Jan.31	59	98	66
	Feb.20	42	54	40
	Mar.12	64	49	66

Reference to Table XXXII shows that the 6" thinning treatment had the highest carotene content at the majority of

the sampling dates in the case of the leaf components whilst the unthinned treatment had the highest content in both stem components. The carotene contents showed no clearly defined trends with advancing season in either of the component parts or in the whole plant. Between the component parts, it was evident that the leaf components were much higher in carotene content than either of the stem components.

(c) Discussion of Results

Dry Matter Percentages

The dry matter percentages obtained for marrow-stem kale were in general agreement with those quoted by Edin et al. (1933), Kivimäe (1950), Axelsson (1949) and Fagan et al. (1943) (see Table II). In many cases, though, the upper range of percentages quoted by these workers was higher than was found in the present trial. However, in the latter, the crop was sampled at an earlier stage of growth and several authors have found that dry matter percentages increased with time (Schmidt and Schleinitz (1933), Woodman et al. (1936), Watson and Horton (1936) and Edin et al. (1933)). Present results from the unthinned treatment were in accordance with this, but no clear-cut trend was apparent in the other treatments. It is conjectural whether such a trend would have occurred in these treatments, had the sampling period been extended. Kivimäe (1950) reported that in his experiment, percentages did not change systematically throughout the season.

The current finding that thinning caused a decrease in dry matter percentage is in agreement with the findings of Miller (1933), Morrison and Hale (1936) and Fagan et al. (1943, 1945). Contrary to these results, Woodman et al. (1936) found that thinning had little effect. The decrease in dry matter percentages of the stem components with thinning, coupled with the finding that the leaf component percentages were not affected, is in accordance with the work of Fagan et al. (1943) and the N.I.R.D. Report (1946). The latter authors dealt with the stem as a whole.

Since the crude protein content of marrow-stem kale is governed to a large extent by the amount of leaf present, crop variety is important. The variety used in the current trial was "Government Certified Giant Type" selected by Calder (1939, 1944). It was therefore probably of a different type than the varieties used in the overseas trials and it is not considered to have a high leaf to stem ratio. Both Calder and Robinson (1950, 1952) found that the leaf to stem ratio of the Giant type was lower than the "Government Certified Medium-stemmed Type".

The decrease in crude protein percentage with advancing season as has been noted, was in accordance with Fagan et al. (1943), Schmidt and Schleinitz (1933) and Kivimäe (1950), though the latter found that the percentages eventually reached a constant level. The decrease was attributed chiefly to shedding of the protein-rich leaves. This is borne out in the current trial as the leaf percentages by weight showed a decrease from beginning to end of the sampling period.

Though Woodman et al. (1936) did not find conclusive results as to whether thinning influenced the crude protein content of the plant, the present finding that thinning caused an increase was in agreement with Morrison and Hale (1936, 1937), Fagan et al. (1943, 1945), the N.I.R.D. Report (1946). The N.I.R.D. Report, which further showed that thinning had its greatest effect on the stem, was borne out.

Present results confirmed reports by Edin et al. (1933), Bünger et al. (1933, 1935) and the N.I.R.D. Report (1946) that leaf was superior to stem in crude protein content. Though lower leaf had slightly smaller percentages than upper stem, the

above general conclusion is not affected because of the very small amounts of lower leaf obtained in the samples. The marrow-rich upper stem had higher percentages than the rind-rich lower stem and this is in accordance with Fagan et al. (1943) and Woodman et al. (1936), who both found that marrow had a higher content of crude protein than rind.

Over the sampling period, yields of crude protein from the plants taken as a whole increased(see Table XXV). This was due to the stem components whose slightly decreasing crude protein percentages with time were offset by increasing dry matter yields. The net result was therefore an increase in yield of crude protein. Both stem components gave approximately equal yields of crude protein. Lower-leaf yields soon declined to zero, whilst upper-leaf yields remained at a relatively constant level. Thinning caused a very slight increase in crude protein yields of the whole plants. Since the dry matter yields were not affected by thinning, this increase was due to the slight trend of increasing crude protein percentages with thinning observed in the stem components. Crude protein yields from upper leaf were not affected by thinning. Even at six months of age, when considerable leaf shedding had taken place, upper leaf — which outyielded both stem components throughout the trial — accounted for almost half of the crude protein yield of the plant. The importance of the proportion of leaf to stem in the evaluation of marrow-stem kale as a food for animals is therefore obvious.

Crude Fibre

Present crude fibre percentages obtained for the whole

plant were comparable with those quoted by Kirsch and Jantzon (1935), Schmidt and Schleinitz (1933) and Fagan et al. (1943, 1945). They were however higher than those found by Woodman et al. (1936), Watson and Horton (1936) and Edin et al. (1933). In view of the variation in crude fibre content between different workers both in the same country and in different countries, it is possible that crop variety may be an important factor. However, crude fibre, and other chemical constituents, can also be influenced by other biological factors, soil factors and climatic factors.

No change in crude fibre percentage with advancing season was noted in the current investigation and this was in agreement with the results of Edin et al. (1933), Woodman et al. (1936) and Fagan et al. (1943). Only Kivimäe (1950) reported a steady increase in crude fibre content with advancing season. The nature of the crude fibre can change with time, though such a change would not affect the crude fibre percentage as detected by routine analysis, since the separation of carbohydrates into nitrogen-free extract and crude fibre is purely empirical.

Thinning did not affect the crude fibre content and this was in accordance with Woodman et al. (1936) and Morrison and Hale (1936, 1937). However, Miller (1933), Krosby and Ulvesli (1953) and Fagan et al. (1943) reported that thinned marrow-stem kale had a lower crude fibre content than unthinned. The latter workers also noted this to be the case in both leaf and stem. Present results showed that thinning had not affected the crude fibre content in any of the component parts.

Leaf was found to be lower in crude fibre content than stem and this finding agreed with those of Wöhlbier and Schramm (1934), the Rothamsted Annual Report (1932) and Fagan et al. (1943). In accordance with the results of Woodman et al. (1936) and Fagan et al. (1943) that marrow had a lower crude fibre percentage than rind, it was found that marrow-rich upper stem had a lower crude fibre percentage than rind-rich lower stem.

The yields of crude fibre increased in the whole plants throughout the sampling period. This was due to the stem components whose yields increased, whilst those of lower leaf declined to zero and those of upper leaf remained relatively constant. Thinning caused a very slight decrease in crude fibre yield, chiefly because of a slight trend of decreasing crude fibre percentages with thinning observed in the stem components. Yields of crude fibre from upper leaf were not affected by thinning. Reference to Table XXV shows that the lower-stem yields of crude fibre accounted for just over half of the total crude fibre content of the plant on the majority of the sampling dates. Leaf only accounted for a very small proportion of the total, especially in the later stages of the trial.

Ether Extract

The whole-plant ether extract percentages found in the present trial were comparable with those quoted by Watson and Horton (1936) and Kivimäe (1950), but much lower than those quoted by Edin et al. (1933), Schmidt and Schleinitz (1933) and Fagan et al. (1943). Crop variety and stage of maturity may be

important in this respect since the leaves have the highest ether extract content of any of the component parts of the plant. Consequently, the leaf to stem ratio will affect the ether extract content of the plant.

A tendency to decrease with advancing season was noted at the beginning of the current trial, but was not continued throughout. Kivimäe (1950) and Schmidt and Schleinitz (1933) have reported a decrease in ether extract content with advancing season.

Thinning was found to have no effect on the ether extract percentage and this was in agreement with Edin et al.(1933). However, Woodman et al. (1936) found that thinning caused a decrease whilst Fagan et al. (1943) found that thinning caused an increase. Results from the latter workers further showed that thinning had affected the stem component but not the leaf. Present results showed that none of the component parts were affected by thinning.

The present finding that leaf had higher ether extract percentages than stem confirmed the findings of Woodman et al.(1933) and Fagan et al. (1943).

The yields of ether extract from the whole plants increased slightly over the sampling period chiefly because of the stem components, whose yields increased whilst those of lower leaf decreased to zero and those of upper leaf remained relatively constant. The chief source of ether extract was the leaf which considerably outyielded both stem components. The stem-component yields did not differ much. Proportionately, leaf accounted for more than half of the total yield of the plant. Thinning did

not affect the yields of any of the component parts.

Mineral Matter

The value of marrow-stem kale as a source of minerals was borne out in the present investigation. In general, the mineral matter percentages of the whole plants were comparable to the majority of the values quoted in Table II (Schmidt and Schleinitz (1933), Kivimäe (1950), Watson and Norton (1936) and Woodman et al. (1936)). Since the leaves are the mineral-rich part of the plant, crop variety may be important. The stem also makes a useful contribution though.

Apart from the early stages, no real tendency to decrease with time was noted. Contrary to this, a decrease with advancing season has been reported by Edin et al. (1933), Kivimäe (1950) and Fagan et al. (1943).

The finding of Woodman et al. (1936) that thinning had no effect on the mineral matter percentage was confirmed. Contrary to this, Fagan et al. (1943, 1945) found that thinning increased the percentage whilst according to results from Finnish trials quoted by Edin et al. (1933), thinning decreased the percentage.

The superiority of the leaf over stem as regards mineral content was in accordance with Woodman et al. (1936) and Fagan et al. (1943). These workers found that marrow had a higher content of mineral matter than either leaf or rind. Consequently, the high marrow content of upper stem may account for the high figures obtained relative to lower stem.

The yields of mineral matter increased in the whole plants throughout the sampling period due to the increase in dry matter yields of stem components; the mineral matter percentages of the latter remained relatively constant. Lower stem yielded slightly more than upper stem and it was only in the later stages of the trial that the stem components outyielded upper leaf. Thinning caused a slight decrease in mineral matter yields. Since dry matter yields were not affected by thinning, the decrease was chiefly because of the slight trend of decreasing mineral matter percentages with thinning in the stem components. Thinning did not affect yields of upper leaf. Proportionately, upper leaf accounted for more of the total yield of mineral matter at the beginning of the sampling period than either of the stem components, but by the end, upper leaf, upper stem and lower stem were making approximately equal contributions to the total.

Nitrogen-free Extract

The nitrogen-free extract percentages obtained in the current trial for whole plants were comparable with those quoted by Bünger et al. (1933) and Schmidt and Schleinitz (1933), but were lower than those quoted by Edin et al. (1933), Watson and Horton (1936) and Kivimae (1950).

No change with advancing season was noted in the present trial and this was in accordance with Woodman et al. (1936). However, Edin et al. (1933), Schmidt and Schleinitz (1933) and Fagan et al. (1943) found an increase with advancing season. Kivimäe (1950) found that the nitrogen-free extract

content was at its highest level in mid-season. The increase with advancing season noted by these authors may be connected with leaf shedding and the consequent reduction in leaf to stem ratio, as it has been shown that stem has a higher nitrogen-free extract content than leaf (Fagan *et al.* (1943)). Present results showed that the nitrogen-free extract of the component parts did not differ by much, whilst Woodman *et al.* (1936) found little difference between marrow, rind and leaf. No effect of thinning was noted in the present trial and this was in accordance with Woodman *et al.* (1936). On the other hand, Fagan *et al.* (1943, 1945) found that thinning decreased the content, whilst Edin *et al.* (1933) quoted figures showing that thinning increased the content.

The great range of variation in nitrogen-free extract content of marrow-stem kale shown by the results collated in Table II and by the present trial can probably be explained, at least in part, by the fact that nitrogen-free extract is determined by difference instead of directly in the approved method of analysis. Consequently, it includes the cumulative errors of the other determinations.

Over the sampling period, yields of nitrogen-free extract from the whole plants increased (see Table XXV). This was chiefly due to the stem components, whose relatively level nitrogen-free extract percentages combined with increasing dry matter yields gave a net increase. It was also partly due to upper-leaf yields which increased slightly due to a slight trend of increasing percentages allied to relatively level dry matter yields. Lower-leaf yields soon declined to zero. Thinning

did not affect the level of yields in the upper leaf though it caused a slight decrease in the stem components. Proportionately, leaf accounted for slightly more nitrogen-free extract than either of the stem components at the beginning of the sampling period, but by the end, both stem components had outyielded upper leaf. At all sampling dates, lower stem accounted for a greater proportion of the total than lower stem.

Carotene

Reference to Table XXII shows that the range of variation of the carotene content of the whole plants, all treatments included, was 40 to 98 micrograms per gram of dry matter. This range was slightly less than that found by Kivimäe (1950), whose values ranged from 60 to 121 over a four-year period. Contrary to the present finding that the carotene content did not change systematically during the sampling period, Kivimäe found a decrease from beginning to end of his period. His crop was at a more mature stage of growth than the present one.

C H A P T E R V

PALATABILITY AND DIGESTIBILITY

This section will be presented in three parts as follows:

(a) Palatability.
   (i) Experimental materials and methods.
   (ii) Experimental results.

(b) Digestibility.
   (i) Experimental materials and methods.
   (ii) Experimental results.

(c) Discussion of the results from the palatability and digestibility trials.

(a) Palatability

To obtain information on the relative palatabilities of the three treatment types of marrow-stem kale, an experiment using sheep as experimental animals was designed. The sheep were given access to one or other of the three types of feed.

(i) Experimental Materials and Methods

Animals

From a flock of fifty mature New Zealand Romney wether sheep, twelve animals were provisionally selected for the experiment. In order to reduce individual variability as much as possible, the animals were chosen for similarity in age, weight and general condition. After a period of "acclimatisation" in the feeding shed, the final choice of the nine sheep required for the actual trial was made. The sheep had previously been grazing ryegrass-clover swards at Grasslands Division and all appeared to be in good health.

Housing

The sheep were housed in a shed normally used for cattle feeding trials; the stalls were converted to individual sheep pens and slatted wooden boards were used to raise the animals off the concrete floor. The conventional type of feeding box for digestibility trials was originally employed, but was found to be unsatisfactory; consequently, feeding racks of large-gauge wire mesh were constructed. Sacking was stretched below this and held in position by a wooden bar at breast height; this prevented soiling of food pulled from the rack. Fresh

water was available at all times.

Feeds

Marrow-stem kale for the first pre-experimental and first experimental feeding periods was obtained from land adjacent to the experimental area, in the same paddock. This crop was sown in September, was unthinned and utilization by dairy cows was begun in January. In further reference to this crop, the term "non-experimental" marrow-stem kale will be used.

For the second pre-experimental and second experimental periods, marrow-stem kale not reserved for yield determinations was used from the experimental plots (see fig. 2). The three treatment types of marrow-stem kale were taken from one block each day and the blocks were used in continuous rotation, so that any one block was used once in four days.

Application of Treatments

To allow for variability in individual intake, a covariance design (Snedecor, 1956 pp.394 et sqq.) was utilized. The nine experimental sheep, designated nos. 1 to 9 respectively on the basis of liveweight, were divided into three groups. Within each group, the treatments were allocated at random, giving a total of three replicates (Table XXXIII). The sheep were randomly allocated to individual pens.

The trial, which began on 21st January 1957 and finished on 22nd February 1957, was divided into four periods; a first pre-experimental period of ten days to allow the sheep to settle down in their new surroundings, become accustomed to handling and to the diet of marrow-stem kale; a first

experimental period of seven days, during which all sheep were fed non-experimental marrow-stem kale. Individual food intakes recorded over this period were used as the independent variables in the covariance analyses; a second pre-experimental period of five days during which sheep nos. 2, 4 and 9 were introduced to unthinned, nos. 1, 6 and 8 to 6" thinned and nos. 3, 5 and 7 to 12" thinned experimental marrow-stem kale respectively; lastly, a second (final) experimental period of ten days during which the three groups, enumerated as above, continued on their respective feeds. Individual food intakes recorded over this period were used as the dependent variables in the covariance analyses.

Table XXXIII

Grouping of the Experimental Animals and Allocation of Treatments

Sheep No.	Group No.	Marrow-stem Kale Treatment
1	I	6" thinned
2		Unthinned
3		12" thinned
4	II	Unthinned
5		12" thinned
6		6" thinned
7	III	12" thinned
8		6" thinned
9		Unthinned

Feeding and Management

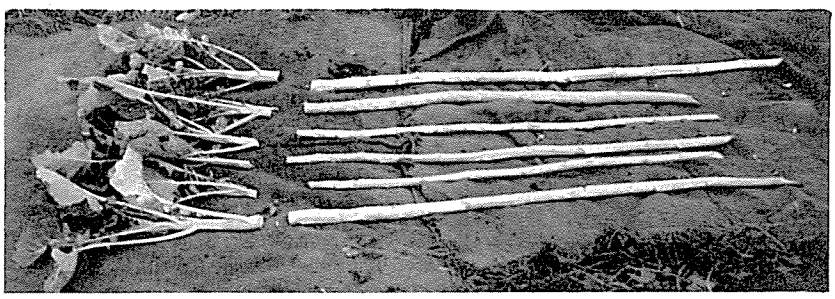
In the first pre-experimental period, the sheep were fed an admixture of marrow-stem kale and herbage for a few days. Herbage was then cut out completely and marrow-stem kale became the sole feed. In trials conducted by Woodman et al. (1936), it was stated that no difficulty was experienced in securing complete consumption of rations of unthinned and thinned marrow-stem kale, whose stems were cut into short lengths. Consequently, in the present trial, a turnip slicing machine was used to chop the marrow-stem kale stems before feeding. However, extreme selectivity resulted and only leaves and the soft upper parts of the stems were eaten; the fibrous lower parts of the stems were left. Frequently, the outer skin of this part was gnawed through to the woody xylem and sometimes the inner soft marrow of the stalk was nibbled from the ends of pieces of stem. When the conventional type of digestibility feeding box was used, the food was often scattered over the pen floor and soiled, so these boxes were replaced by feeding racks and sacking as already described.

To secure adequate intakes of marrow-stem kale under these conditions of selectivity, it was necessary to feed quantities in excess of that calculated to supply maintenance requirements. When the calculated quantities were given, intakes fell below that required for maintenance. Intakes similarly fell when marrow-stem kale stems only were given, in an attempt to accustom the sheep to eating stems. It was therefore decided to feed only the upper part, including leaves, of the marrow-stem kale and to stop chopping the stems, as this did not appear to have any advantage. The point chosen to divide the upper from the

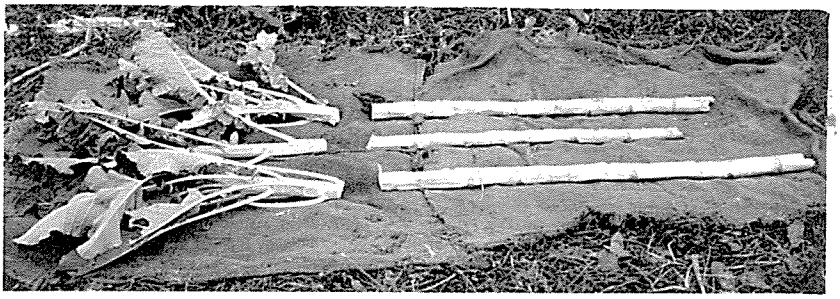
lower part of the plant was where the lowest leaf was still attached to the stem. This point had the advantage of being clearly defined and was adhered to throughout the remainder of the trial. The cutting points and examples of the three types of experimental feeds are shown in figs. 16 and 17 respectively.

The wastage in utilization (dry matter basis) with this method was 59% for the non-experimental marrow-stem kale; 58%, 56% and 51% respectively for the unthinned, 6" thinned and 12" thinned experimental marrow-stem kale. These percentages represented the means of samples taken daily during the course of the experiment. Samples of the feeds were analysed daily for leaf to stem ratios. On a dry matter basis, the leaf to stem ratios were 63 to 37, 56 to 44 and 53 to 47 for the respective experimental feeds in order as above. The non-experimental marrow-stem kale gave a leaf to stem ratio of 62 to 38.

The total amount of marrow-stem kale required to feed the sheep daily was hand cut with a sickle and transported to the feeding shed prior to the morning feed. To prevent excessive wilting during the day, the feed was stored on the concrete floor in a cool part of the shed and covered with damp sacking. A daily ration of 25 pounds fresh marrow-stem kale was fed in weighed 10, 5 and 10 pound amounts at 9 a.m., 1 p.m., and 5 p.m. respectively to each sheep. At the end of each 24-hour period, this is, just before the 9 a.m. feed, individual refuse weights were recorded. All weighings were made on a Salter Milk Scale Balance, which could be read to an accuracy of 0.1 pounds.



(a) Unthinned



(b) 6" thinned

(c) 12" thinned

Figure 16

Cutting-points of the Three Experimental Types of Marrow-stem Kale for Feeding to the Sheep (20th Feb. 1957)

(a) Unthinned

(b) 6" thinned

(c) 12" thinned

Figure 17

The Three Types of Experimental Feed

Sampling of Feeds and Refuses

Throughout the trial period 300-gram representative samples of the feeds and individual refuses were taken daily and dried in a forced draught type of hot air oven at 173°F for twelve hours. The samples were then weighed and the resultant dry matter percentages used to calculate daily individual dry matter intakes of each animal. All weighings were made on an E.T.A. Triple Beam Balance, which could be read to an accuracy of 0.1 grams. The samples taken during the final experimental period were ground in a laboratory mill after drying and stored in sealed glass jars for future chemical analyses. This was done as this period was used to determine the digestibilities of the feeds simultaneously with palatability measurements.

Weighing of Animals

The liveweight of each sheep was recorded immediately prior to the morning feed on four occasions during the trial; namely, at the beginning and end of the first and final experimental periods respectively. A spring balance with sling harness (fig. 18), suspended from a roof beam, was used. By this means, sheep were weighed in their individual pens with minimum disturbance.

Collection of Data

The following information was recorded during the trial:

(a) The behaviour, general condition and health of the sheep.

(b) The daily individual intake and refuse weights of fresh marrow-stem kale, of each sheep.

(c) The dry matter contents of the daily feeds and refuses, of each sheep.

(d) The daily individual intake and refuse weights of marrow-stem kale dry matter, of each sheep.

(e) The liveweight of each sheep at the beginning and end of the first and final experimental periods respectively.

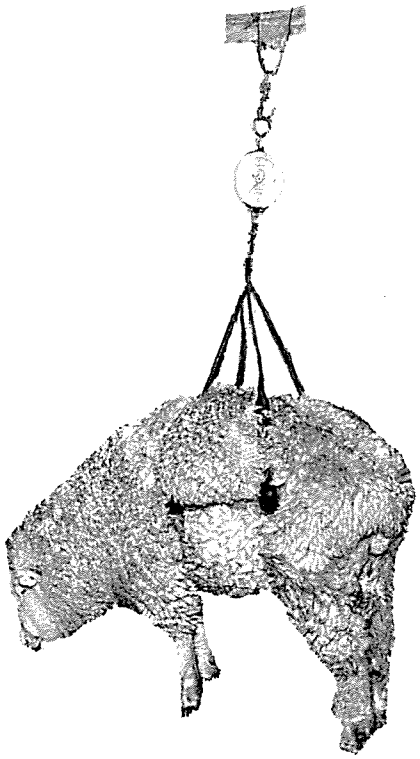


Figure 18

Weighing the Experimental Sheep

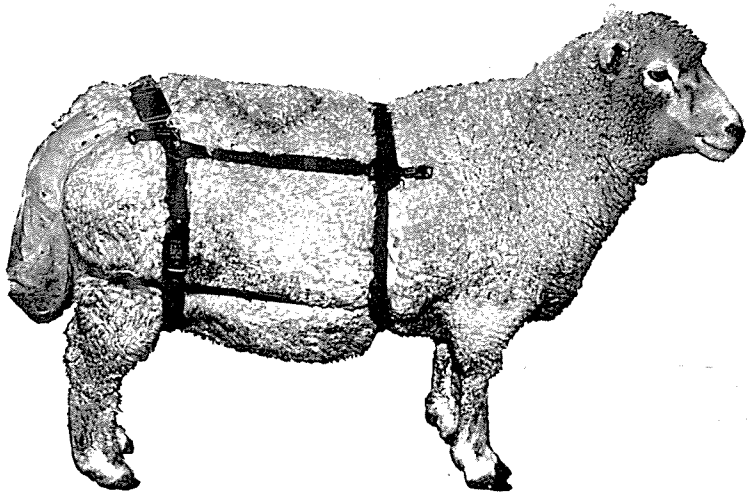


Figure 19

Experimental Sheep Fitted with
Harness for Collection of Faeces

(11) Experimental Results

General Observations

Once the initial difficulties, outlined under the feeding and management section, had been overcome, the feed intakes reached a satisfactory level. All sheep showed slight day-to-day fluctuations in individual intake and there was also some variation though not extreme, in the intakes between sheep. Compared with the first experimental period, mean daily intakes of fresh marrow-stem kale during the final experimental period decreased slightly in all groups, except that fed unthinned marrow-stem kale, where a slight increase occurred. On a dry matter basis, intakes increased slightly in all groups except that fed 12" thinned marrow-stem kale, where a negligible decrease (.02 pounds) occurred.

Selection was practised to a certain degree in that all the leafage was consumed, so that the refuses were usually composed of pieces of stem. Sheep no.4 was least selective and its refuse contained both leaf and stem. No apparent decline in appetite during the course of the experiment was observed. The sheep settled down very well and soon became accustomed to frequent handling. All maintained good condition and health.

Feed Consumtpion - Fresh Marrow-stem Kale

Total and mean daily intakes of fresh marrow-stem kale, by each animal during the first and final experimental periods, are presented in Table XXXIV and XXXV respectively. Individual day-to-day feed intake records for the same periods are lodged with the Field Husbandry Department, Massey Agricultural College.

Table XXXIV

Total and Average Daily Fresh and Dry Matter Intakes and Changes in Liveweight of Sheep fed Non-experimental Marrow-stem Kale during the 7-day First Experimental Period

Sheep No.	Total Fresh Matter Intake lbs.	Average Daily Fresh Matter Intake lbs.	Total Dry Matter Intake lbs.	Average Daily Dry Matter Intake lbs.	Liveweight at Start of Period lbs.	Gain (+) or Loss (-) in Weight lbs.
2	149.15	21.31	17.71	2.53	127.5	-1.5
4	115.40	16.49	14.41	2.06	131.0	-2.5
9	164.45	23.49	19.46	2.78	151.5	+1.0
1	121.65	17.38	14.74	2.11	122.0	-3.0
6	119.05	17.01	14.55	2.08	136.5	-3.5
8	155.00	22.14	18.29	2.61	147.0	-2.0
3	160.30	22.90	19.03	2.72	130.5	+1.0
5	155.35	22.19	18.56	2.65	132.5	+1.0
7	134.95	19.28	16.50	2.36	139.0	-2.5

Table XXXV

Total and Average Daily Fresh and Dry Matter Intakes and Changes in Liveweight of Three Groups, each of 3 Sheep, fed Experimental Marrow-stem Kale over the 10-day Final Experimental Period

Marrow-stem Kale Type	Sheep No.	Total Fresh Matter Intake lbs.	Average Daily Fresh Matter Intake lbs.	Total Dry Matter Intake lbs.	Average Daily Dry Matter Intake lbs.	Liveweight at Start of Period lbs.	Gain (+) or Loss (-) in Weight lbs.
Unthinned	2	222.45	22.25	27.67	2.77	126.0	-1.0
	4	186.05	18.61	23.34	2.33	128.5	-4.0
	9	244.55	24.46	29.98	3.00	152.5	+3.0
6" thinned	1	119.75	11.98	19.24	1.92	119.0	-5.5
	6	158.75	15.88	23.55	2.36	133.0	-3.5
	8	229.75	22.98	30.29	3.03	145.0	+3.0
12"thinned	3	204.25	20.43	27.63	2.76	131.5	-1.0
	5	173.00	17.30	24.54	2.45	133.5	-2.5
	7	172.70	17.27	24.65	2.47	136.5	-2.0

During the 7-day first experimental period, the mean daily consumption of all groups was 20.2 pounds of non-experimental marrow-stem kale. The mean daily consumptions of the three groups, each of three sheep, selected to receive unthinned, 6" thinned and 12" thinned marrow-stem kale respectively during the final experimental period, were 20.4, 18.8 and 21.5 pounds respectively.

During the 10-day final experimental period, respective mean daily consumptions of the three groups, in order as above, were 21.8, 17.0 and 18.3 pounds. The unadjusted mean intake of unthinned marrow-stem kale was therefore 4.8 and 3.5 pounds greater than the intakes of 6" thinned and 12" thinned marrow-stem kale respectively.

The analysis of covariance, test of significance of the adjusted mean intakes of the three feeds and the analysis of error variance are presented in Appendix 11. Results showed that intake differences between the groups were not significant. In the analysis of error variance, although the reduction in sums of squares due to regression was not significant, the mean square for error was reduced from 1341.99 to 646.27; this indicated that the use of covariance had increased the precision of the experiment. The efficiency of covariance relative to analysis of variance was 208%. Without covariance therefore, 108% more animals would have been required to achieve the same precision.

Total mean daily intakes of the three feeds, unadjusted and adjusted for regression, are presented in Table XXXVI.

Table XXXVI

Unadjusted and Adjusted Mean Total and Daily Fresh Marrow-stem Kale Intakes over the Final Experimental Period

Marrow-stem Kale	Total Intake/ Sheep Unadjusted lbs.	Daily Intake/ Sheep Unadjusted lbs.	Total Intake/ Sheep Adjusted lbs.	Daily Intake/ Sheep Adjusted lbs.
Unthinned	217.68	21.77	215.83	21.58
6" thinned	169.48	16.95	183.89	18.39
12"thinned	183.32	18.33	171.25	17.13

Although the mean differences between adjusted intakes were not significant, the existence of differences between the unadjusted and adjusted mean intakes provided further evidence that the use of covariance had increased the precision of the experiment.

Dry Matter Content of Feeds and Refusals

Mean dry matter percentages of the non-experimental and experimental feeds, offered to and refused by each sheep during the first and final experimental periods, are presented in Tables XXXVII and XXXVIII respectively. Individual day-to-day dry matter percentages of the feeds offered and refused are lodged with the Field Husbandry Department, Massey Agricultural College. These values were used to determine the dry matter consumption of each sheep over the experimental periods.

The dry matter percentage of the non-experimental feed was slightly lower than the percentages of the experimental feeds.

Table XXXVII

Mean Dry Matter Percentages of Non-experimental Marrow-stem Kale Offered to and Refused by the Sheep during the 7-day First Experimental Period (moisture-free basis)

Marrow-stem Kale	Unthinned			6" thinned			12" thinned		
Sheep No.	2	4	9	1	6	8	3	5	7
Feed Dry Matter %	11.75	11.75	11.75	11.75	11.75	11.75	11.75	11.75	11.75
Refuse Dry Matter %	11.03	10.32	10.43	10.91	10.74	11.35	10.41	10.18	10.14

Table XXXVIII

Mean Dry Matter Percentages of Experimental Marrow-stem Kales Offered to and Refused by the Sheep during the 10-day Final Experimental Period (moisture-free basis)

Marrow-stem Kale	Unthinned			6" thinned			12" thinned		
Sheep No.	2	4	9	1	6	8	3	5	7
Feed Dry Matter %	12.23	12.23	12.23	12.97	12.97	12.97	12.94	12.94	12.94
Refuse Dry Matter %	10.56	11.32	11.01	10.13	9.73	10.67	10.32	10.14	9.96

With unthinned marrow-stem kale, this difference was less than 1% and with the 6" and 12" thinned marrow-stem kales, the difference was just over 1%.

During the first experimental period, the mean dry matter percentage of each sheep's refuse was less than that of the feed, but only by just over 1% in most cases. Similarly, refuse dry matter percentages were lower than those of the corresponding feeds by amounts ranging from 0.91% to 3.24%, during the final experimental period. The lower values recorded for refuses indicated that the sheep were selective to a certain degree. All the leafage was eaten and refuses consisted mainly of pieces of stem; the refuse of sheep no.4, the least selective, was, as would be expected, closest to the feed in dry matter percentage. Stem had already been found to be lower in dry matter percentage than leafage (see pp.69-73).

Feed Consumption - Marrow-stem Kale Dry Matter

Total and mean daily intakes of marrow-stem kale dry matter by each animal during the first and final experimental periods, are presented in Tables XXXIV and XXXV respectively. Individual day-to-day feed intake records for the same periods are lodged with the Field Husbandry Department, Massey Agricultural College.

During the 7-day first experimental period, the mean daily consumption of all groups was 2.43 pounds of non-experimental marrow-stem kale dry matter. The mean daily consumptions of the three groups, each of three sheep, selected to receive unthinned, 6" thinned and 12" thinned marrow-stem kale during the final experimental period, were, 2.45, 2.27 and 2.58 pounds respectively.

During the 10-day final experimental period, respective mean daily consumptions of the three groups, in order as above, were 2.70, 2.44 and 2.56 pounds. The unadjusted mean intake of unthinned marrow-stem kale was therefore 0.26 and 0.14 pounds greater than the intake of 6" thinned and 12" thinned marrow-stem kale respectively.

The analysis of covariance, test of significance of the adjusted mean intakes of the three feeds and the analysis of error variance are presented in Appendix 12. Results showed that intake differences between the groups were not significant. In the analysis of error variance, although the reduction in sums of squares due to regression was not significant, the mean square for error was reduced from 14.41 to 5.96; this indicated that the use of covariance had increased the precision of the experiment. The efficiency of covariance relative to analysis of variance was 242%. Without covariance therefore, 142% more animals would have been required to achieve the same precision.

Total mean daily intakes of the three feeds, unadjusted and adjusted for regression, are presented in Table XXXIX.

Although the mean differences between adjusted intakes were not significant, the existance of differences between the unadjusted and adjusted mean intakes provided further evidence that the use of covariance had increased the precision of the experiment.

Table XXXIX

Unadjusted and Adjusted Mean Total and Daily Marrow-stem Kale Dry Matter Intakes over the Final Experimental Period

Marrow-stem Kale	Total Intake/ Sheep Unadjusted lbs.	Daily Intake/ Sheep Unadjusted lbs.	Total Intake/ Sheep Adjusted lbs.	Daily Intake/ Sheep Adjusted lbs.
Unthinned	27.00	2.70	26.76	2.68
6" thinned	24.36	2.44	26.09	2.61
12" thinned	25.61	2.56	24.13	2.41

Changes in Liveweight

The liveweight of each sheep at the beginning of the first and final experimental periods and the change over these periods are presented in Tables XXXIV and XXXV respectively.

During the first experimental period, small apparent weight losses were recorded for sheep nos. 1, 2, 4, 6, 7 and 8; small apparent weight gains were recorded for sheep nos.3, 5 and 9. All sheep except nos. 8 and 9 showed small apparent weight losses during the final experimental period.

On average, apparent weight losses were recorded for all groups in each experimental period; the losses were very small. However, variation in initial liveweight, individual intake, water consumption and "gut" fill could be among contributory factors obscuring the liveweight changes, so that no significance was read into the apparent liveweight gains and losses.

(b) Digestibility

The sheep employed for palatability measurements were simultaneously used during the latter two periods, that is, second pre-experimental and final experimental, of the palatability trial to determine the relative digestibilities of the different conventional feed constituents in the three experimental types of marrow-stem kale feed. From these, by standard procedures, the starch equivalents, total digestible nutrient contents, digestible crude protein contents and the nutritive ratios were calculated.

(i) Experimental Materials and Methods

The experimental materials, namely, animals, housing and feeds, have been already described in the previous section on palatability.

Application of Treatments

The grouping of the animals and allocation of treatments have been already described (see p.109). The design was thus a randomized block type, with three sheep per block, within which the treatments had been randomly allocated (Snedecor, 1956, pp. 291 et sqq.).

The trial which began on 7th February 1957 and finished on 22nd February 1957 was comprised of the latter two periods of the palatability trial, namely, the second preliminary period of five days and the final experimental period of ten days. Individual feed intakes and faecal outputs during the 10-day experimental period were used in the digestibility determinations.

The apparent digestion coefficients of each feed were determined in triplicate, using sheep nos. 2, 4 and 9 for unthinned, 1, 6 and 8 for 6" thinned and 3, 5 and 7 for 12" thinned marrow-stem kale respectively.

Feeding and Management, Sampling of Feeds and Refuses, Weighing of Animals

The techniques employed in these duties have been already described (see pp.111-113).

Collection and Sampling of Faeces

Digestibilities were determined using the conventional method of total collection of the faeces. The apparatus used was that described by Sears and Goodall (1942); it consisted essentially of a leather harness with attached rubberized canvas bags for collecting the faeces (fig. 19). Since neither nitrogen nor mineral balances were undertaken, urine was not collected.

The animals were harnessed during the preliminary period of the trial and soon became accustomed to wearing the harness and to the frequent handling associated with its use. The collection bags were emptied three times daily, once prior to the first and third feeding times and at 9 p.m. The faeces from each animal was individually weighed at these times, stored in plastic containers and kept in a cool part of the shed. Daily, the total wet faeces voided by each sheep was mixed thoroughly and sampled by taking an aliquot part equal to one tenth of the total. To determine dry matter contents, the samples were dried in a forced-draught type of hot air oven at

173°F for twelve hours. The samples were then crushed and dried for another twelve hours, as there was a tendency for the surface of the faeces to become dry and hard, thereby preventing the inner material from drying out. After weighing, the samples were ground in a laboratory mill and stored in sealed glass jars for future chemical analyses. All weighings were made on an E.T.A. Triple Beam Balance, which could be read to an accuracy of 0.1 grams.

Chemical Analyses

Composite samples of the three marrow-stem kale feeds, individual refuses and individual faeces were made up from the daily samples taken during the collection period. All analyses were done in duplicate on representative samples by the method recommended by the Association of Official Agricultural Chemists (1952).

Collection of Data

The following information was recorded during the trial:

(a) The behaviour, general condition and health of the sheep.

(b) The daily individual intake and refuse weights of fresh marrow-stem kale, of each sheep.

(c) The dry matter contents of the daily feeds and refuses, of each sheep.

(d) The daily individual intake and refuse weights of marrow-stem kale dry matter, of each sheep.

(e) The daily amounts of wet faeces voided by each sheep.

(f) The dry matter content of the daily wet faeces of each sheep.

(g) The daily weight of faecal dry matter voided by each sheep.

(h) The liveweight of each sheep at the beginning and end of the experimental period.

Nutritive Value of Feeds

Data recorded as above were used to calculate the apparent digestion coefficients of the different feed constituents in the three feed types of marrow-stem kale.

Values for the total digestible nutrient contents of the feed types were estimated from the method of Woodman (1954); namely, by adding the percentages of digestible ether extract x 2.25, digestible crude protein, digestible crude fibre and digestible nitrogen-free extract respectively.

Starch equivalent values were calculated by the method of Kellner (1915) as outlined by Woodman (1954), that is, by adding the products of digestible crude protein x 0.94, digestible ether extract x 1.91, digestible crude fibre x 1.0 and digestible nitrogen-free extract x 1.0; the total obtained was then multiplied by the correction factor, "V", of 93.

The nutritive ratios were determined according to the expression given by Woodman (1954), viz.,

$$\text{Nutritive Ratio} = \frac{(\%\ \text{dig.ether extract} \times 2.3) + \%\ \text{dig.carbohydrate} + \%\ \text{dig.fibre}}{\%\ \text{dig.crude protein}}.$$

(ii) Experimental Results

Certain experimental results relating to both palatability and digestibility measurements have already been presented in the palatability section. These were as follows:

(a) General observations.

(b) Feed consumption - fresh marrow-stem kale (Table XXXV).

(c) Dry matter content of feeds and refuses (Table XXXVIII).

(d) Feed consumption - marrow-stem kale dry matter (Table XXXV).

(e) Weighing of animals (Table XXXV).

With reference to the latter and to the apparent digestion coefficients to be presented in succeeding pages, there did not appear to be any relationship between digestibilities of the feeds and liveweight changes. It may again be emphasized that factors did exist which could conceivably have caused liveweight fluctuations.

Composition of Feeds, Refuses and Faeces

The chemical composition of the three marrow-stem kale feeds, together with that of the refuses and faeces of each sheep are presented in Table XL.

Feed analyses showed that the chemical composition of the three feeds was essentially similar. There was a slight trend apparent, however, of decreasing percentages of the feed constituents with increasing severity of thinning, except nitrogen-free extract and organic matter, with which the position was reversed.

Table XL

Chemical Composition of Feeds, Refuses and Faeces
(stated as % - on a moisture-free basis)

Marrow-stem Kale	Sheep No.	Percentage Composition						
		Dry Matter	Crude Protein	Crude Fibre	Ether Extract	Nitrogen-free Extract	Mineral Matter	Organic Matter
		(a) Feed Analyses						
Unthinned	-	12.2	15.0	15.7	2.7	52.5	14.1	85.9
6" thinned	-	13.0	14.9	15.6	2.7	53.0	13.8	86.2
12" thinned	-	12.9	14.7	15.6	2.6	55.0	12.1	87.9
		(b) Refuse Analyses						
Unthinned	2	10.6	9.4	19.4	1.0	58.2	12.0	88.0
	4	11.3	14.7	15.8	2.2	53.4	13.9	86.1
	9	11.0	9.7	21.9	1.4	54.8	12.2	87.8
6" thinned	1	10.1	11.3	18.8	1.0	56.2	12.7	87.3
	6	9.7	11.3	21.0	0.8	54.6	12.3	87.7
	8	10.7	11.2	25.6	1.3	50.5	11.4	88.6
12" thinned	3	10.3	10.3	23.9	1.2	53.0	11.6	88.4
	5	10.1	10.7	21.9	1.1	54.0	12.3	87.7
	7	10.0	11.2	23.2	1.5	51.5	12.6	87.4
		(c) Faeces Analyses						
Unthinned	2	23.7	17.1	11.2	9.6	28.6	33.5	66.5
	4	38.7	14.3	11.6	11.2	29.1	33.8	66.2
	9	29.6	16.5	13.2	9.5	32.6	28.2	71.8
6" thinned	1	35.5	12.5	9.5	13.3	22.9	41.8	58.2
	6	31.1	15.6	9.9	11.7	28.3	34.5	65.5
	8	31.3	14.6	12.8	9.7	33.2	29.7	70.3
12" thinned	3	43.5	14.3	12.0	9.5	25.7	38.5	61.5
	5	39.9	14.1	12.4	10.3	31.6	31.6	68.4
	7	31.1	15.5	12.4	11.8	21.4	38.9	61.1

Refuse analyses showed that individual refuses of all animals except sheep no.4 were lower in crude protein, ether extract and mineral matter contents and higher in crude fibre contents than the corresponding feeds. This was further indication that selective feeding was practised to a certain degree by all animals except sheep no.4, whose refuse analysis closely approximated that of the feed.

Although exhibiting some variability, particularly in the dry matter content, the composition of the individual faecal outputs did not differ greatly. In all cases, the dry matter, ether extract and mineral matter contents of the individual faecal outputs were much higher than the corresponding feeds; crude protein was only sometimes higher, whilst the nitrogen-free extract and crude fibre contents were always lower.

Digestion Coefficients of the Feed Constituents

The apparent digestion coefficients of the feeds were calculated by using the data for each sheep pertaining to the amounts of dry matter offered, refused and excreted, together with their respective compositions. Detailed calculations of the coefficients and the analyses of variance to which they were subjected are presented in Appendices 13 and 14 respectively. The mean apparent digestion coefficients of the various feed constituents in the three feeds are presented below in Table XLI.

The mean apparent digestion coefficients of all the feed constituents except crude fibre, increased slightly with increasing severity of thinning; differences between coefficients were greatest for the crude protein and ether extract constituents.

Table XLI

Mean Apparent Digestion Coefficients of the Feed Constituents in the Three Types of Marrow-stem Kale Feed

Marrow-stem Kale / Feed Constituents	Unthinned	6" thinned	12" thinned
Dry matter	81.5	82.5	83.7
Crude protein	80.6	84.4	84.9
Crude fibre	85.7	86.5	85.3
Ether extract	35.0	40.8	42.4
Nitrogen-free extract	89.3	90.5	92.3
Organic matter	85.3	86.7	88.2

Reference to the analyses of variance showed that although variation occurred between the feed constituent digestion coefficients for the three types of marrow-stem kale feed, the differences were not significant for any feed constituent (Appendix 14).

Calculated Nutritive Values

The relative nutritive values of the three feeds are presented in Table XLII.

Linked to the essentially similar chemical compositions of the feeds, the trend of increasing mean apparent digestion coefficients with increasing severity of thinning has produced a similar trend in the total digestible nutrient content of the three feeds. The starch equivalent values likewise followed this trend. Only slight differences existed between the

digestible crude protein contents. Based upon Woodman (1954), the nutritive ratios, which were very similar, would all be termed "medium" ratios.

Table XLII

Mean Values for Total Digestible Nutrient Contents, Starch Equivalents, Digestible Crude Protein Contents and Nutritive Ratios of the Three Types of Marrow-stem Kale Feed

(fresh matter basis and dry matter basis)

Marrow-stem Kale	T.D.N./100 lb.		S.E./100 lb.		D.C.P./100 lb.		Nutritive Ratio
	% FM	% DM	% FM	% DM	% FM	% DM	
Unthinned	9.1	74.5	8.4	68.3	1.5	12.1	5.2
6" thinned	9.9	76.5	9.1	70.1	1.6	12.6	5.1
12" thinned	10.2	79.0	9.4	72.4	1.6	12.5	5.3

(c) Discussion of Results

The plan of the experiment proved satisfactory from the viewpoint of examination of the results. In particular, the use of covariance increased the precision of the palatability trial.

The results obtained from the experiment can of course only be strictly applied to the conditions under which the experiment was conducted. These differed from those present under normal grazing of marrow-stem kale by sheep. In the trial, the sheep were not given access to marrow-stem plants as a whole, but were limited to the upper parts. The point chosen to divide the upper from the lower parts of the plant was clearly defined and had the advantage of being capable of repetition. It is probable, judging from the behaviour of the sheep, when initially fed whole marrow-stem kale, that they would select the leaves and relatively soft upper parts of the stem in the field . This is borne out, at least in part, by practical observations. It has also been observed that thickly sown marrow-stem kale, which develops a thin-stemmed crop is utilized to a greater extent in the field than a thinly sown crop which develops thick stems. The increased utilisation of the former is due to more stem being eaten. Consequently, although the results from the trial showed wastage in utilization of 58%, 56% and 51% for unthinned, 6" thinned and 12" thinned marrow-stem kale respectively, these would not necessarily be the figures obtained under normal grazing conditions. Indeed, it is possible that the order of the treatment types of feed would be reversed due to higher utilization of the thin and medium stems of unthinned and 6" thinned

marrow-stem kale respectively. This was certainly the case with dairy cows break-fed on the experimental marrow-stem kale remaining in March after the experiment was finished. By feeding the sheep a fixed ration during the trial instead of *ad libitum*, excessive selection, a factor of particular importance in the determination of digestibility, was prevented.

The differences in fresh and dry matter intakes of the groups of sheep, fed on the three treatment types of marrow-stem kale respectively, did not differ significantly. Consequently, this trial based upon intakes, showed no difference in palatability between the three feeds. Unfortunately, there are no published data available for comparison. The experiment of Woodman *et al.* (1936) was not designed to gain information on palatability, but perusal of respective intakes of unthinned and thinned marrow-stem kale, in their digestibility trials using sheep, showed little difference.

The chemical compositions of the three treatment types of marrow-stem kale fed were essentially similar. In view of this, together with the fact that respective intakes of the groups of sheep fed on the three types of marrow-stem kale did not differ much, it was hardly surprising that little difference existed between the respective feed-constituent digestion coefficients. What differences did exist were of little practical significance. The digestion coefficients obtained showed that the marrow-stem kale fed, was a highly digestible animal feeding-stuff.

The results obtained from the digestibility trial are

not strictly comparable with those presented in Table III, since the latter results were chiefly obtained from marrow-stem kale fed as a whole. However, in spite of this and the fact that the results in Table III vary widely, certain features are of interest.

Crude protein digestion coefficients obtained in the present trial are comparable with those found by Schmidt and Schleinitz (1933), Bünger et al. (1933), Richter and Ferber (1933) and others for marrow-stem kale fed whole and with values recorded by Wöhlbier and Schramm (1934) for marrow-stem kale leaves and stems respectively. This suggests that crude protein throughput the marrow-stem kale plant is equally digestible. However, in other trials by Edin et al. (1933), Watson and Horton (1936) and Kirsch and Jantzon (1935), coefficients, less by varying percentages than those found in the present trial, were recorded. Among possible reasons which may be advanced in explanation, there is the variation among individual animals and the effect of environmental and physiological conditions, including all errors, inherent in work of this nature. There is also the question of plant variety and stage of maturity. Concerning these, it may be pertinent to quote Maynard and Loosli (1956):

"Microbiotic action plays a very large role in connection with the fibrous rations of Herbivora and thus the nature and amount of crude fibre present are important factors governing the extent of the digestibility of the various nutrients in the ration."

Crude fibre digestion coefficients, obtained from the

present trial, were much higher than the majority presented in Table III. Only one trial by Watson and Horton (1936) and one by Kirsch and Jantzon (1935) revealed comparable values. These authors fed whole marrow-stem kale. A comparable value was also obtained by Wöhlbier and Schramm (1934) from a trial in which marrow-stem kale leaves were fed. It is conceivable that the nature of the crude fibre in the feeds of the present trial differed from that of the lower parts of the plant. The crude fibre of the latter would therefore affect the results obtained when whole marrow-stem kale was fed. Again, reference to the section on the composition of experimental marrow-stem kale showed that the crude fibre contents of the present feeds were less than those of whole marrow-stem kale. Indeed they were equivalent to the values obtained for leaf.

The majority of the digestion coefficients for ether extract presented in Table III were higher than those found in the current trial. Kirsch and Jantzon (1935) and Edin and Sunderlin (1930) were exceptions, who obtained lower coefficients. Wöhlbier and Schramm (1934) obtained a comparable value for marrow-stem kale leaves. The ether extract content of the present trial feeds were equivalent to those of marrow-stem kale leaves as revealed by reference to the section on composition of the experimental marrow-stem kale. It may be therefore, that the digestibilities of ether extract in the present trial were influenced by the ether extract intakes, which were greater than those which would be ingested had whole marrow-stem kale been fed. There is also the possible influence of the other feed constituents on the amount of metabolic fat in the faecal ether extract.

The trial yielded high digestion coefficients for nitrogen-free extract, but the figures were still in agreement with the majority tabulated in Table III. This is suggestive that the nitrogen-free extract of the different parts of marrow-stem kale is equally digestible.

The digestion coefficients of the organic matter obtained in the present trial were also in fairly close agreement with the majority presented in Table III. Schmidt and Schleinitz (1933), Edin et al. (1933) and Edin and Sunderlin (1930) obtained much lower values though.

With regard to the calculated nutritive values of the three feeds, the data presented showed no outstanding differences between the three treatment types of marrow-stem kale feed. This was a logical sequel as both the chemical compositions and digestion coefficients of the feeds were essentially similar. For comparison, the relative nutritive values of unthinned and thinned marrow-stem kale calculated by Woodman (1954) are shown in Table XLIII.

On a dry matter basis, Woodman's figures for unthinned and thinned marrow-stem kale were less than those found in the present experiment. This is to be expected as his values were based upon results obtained from feeding whole marrow-stem kale to sheep.

During the present experimental period, liveweight changes in the sheep were recorded. These changes, along with visual observations, served as a guide to the general condition and health of the animals. No significance was read into the

small apparent liveweight gains and losses which did occur. Had such a purpose entered into the plan of the investigation, a different experimental procedure would have been employed.

Table XLIII

Mean Values for Total Digestible Nutrient Contents, Starch Equivalents, Digestible Crude Protein Contents and Nutritive Ratios of Unthinned and Thinned Marrow-stem Kale (Woodman, 1954)

Marrow-stem Kale	T.D.N./100 lb.		S.E./100 lb.		D.C.P./100 lb.		Nutritive Ratio
	% FM	% DM	% FM	% DM	% FM	% DM	
Unthinned	10.1	72.0	9.1	65.0	1.7	12.1	4.9
Thinned	9.9	71.2	9.0	64.8	1.6	11.5	5.2

On the basis of the results obtained from the palatability and digestibility trial therefore, it would appear that thinning of marrow-stem kale, which requires considerable labour and expense, is not justifiable. However, before definite conclusions can be drawn as to whether thinning is of practical use in New Zealand, more critical experimentation with both sheep and cattle is required.

C H A P T E R VI

SUMMARY

(1) A study has been made of the effect of different thinning treatments on the yield, composition, palatability and digestibility of marrow-stem kale grown in rows.

(2) The thinning treatments had no effect on the green matter yields of whole plant, upper leaf, upper stem or lower stem, but lower-leaf yields increased with increasing severity of thinning. Likewise, the treatments had no effect on the dry matter yields of whole plant, upper leaf or lower stem, but lower-leaf yields increased and upper-stem yields decreased, with increasing severity of thinning.

(3) Leaf percentages, both on a green and dry matter basis, tended to increase with increasing severity of thinning, the effect decreasing with advancing season. Further, leaf percentages decreased with time, the greatest rate of decrease occurring at the beginning of the sampling period.

(4) A detailed study of leaf shedding would aid in the interpretation of variation in marrow-stem kale growth.

(5) Thinning decreased the dry matter percentages of the stem components and whole plant, but had little effect on the leaf components.

(6) Thinning increased the crude protein percentages of the stem components and whole plant, but had little effect on the leaf components. No effect of thinning on the crude protein yields of the component parts and whole plant was observed.

(7) Thinning had no effect on the crude fibre percentages of the component parts or whole plant. The crude fibre yields of stem components and whole plant were decreased by thinning, whilst leaf-component yields were not affected.

(8) Thinning had no effect on the ether extract percentages or yields of the component parts and whole plant.

(9) Thinning had no effect on the mineral matter percentages of the component parts or whole plant. Mineral matter yields of the stem components were decreased by thinning, whilst mineral matter yields of lower leaf were increased. Upper-leaf and whole-plant yields were not affected.

(10) Thinning had no effect on the nitrogen-free extract percentages of the component parts or whole plant. Nitrogen-free extract yields of upper leaf and whole plant were not affected by thinning, but stem-component yields were decreased and lower-leaf yields were increased.

(11) No consistent effect of thinning on the carotene content of the component parts or whole plant was observed.

(12) In general, advancing season had little appreciable effect on the percentage composition except in the case of crude protein percentages, which decreased; ether extract and mineral matter percentages also decreased but the changes were slight and occurred only in the initial stages of the sampling period. The yields of all the chemical constituents increased with advancing season. This was due to increasing stem-component yields rather than to leaf-component yields, which remained relatively constant.

(13) Thinning had no effect on palatability as determined by the fresh and dry matter intakes of sheep.

(14) Thinning had little effect on the digestion coefficients of the various feed constituents. Similarly, little effect was observed on the total digestible nutrient contents, starch equivalent values, digestible crude protein contents or nutritive ratios.

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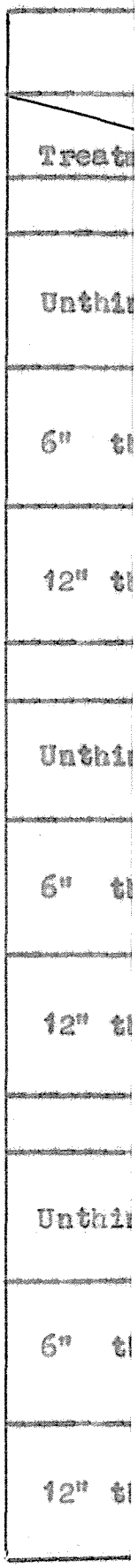
LIST OF APPENDICES

Appendix 1

Weather Data, Grasslands Division Meteorological Station

Week Ending	Rain ins.	Evaporation ins.	Temperatures °F Grass min.	Soil 4"	Soil 12"	Sun Hours
1956						
22 Sept.	.10	.500	34.4	50.6	52.9	53.6
29 Sept.	.63	.529	36.3	53.2	55.2	38.8
6 Oct.	1.42	.515	44.0	54.2	55.8	30.8
13 Oct.	.29	.566	40.0	52.6	54.7	17.4
20 Oct.	.73	.779	39.5	55.6	57.3	45.8
27 Oct.	.25	.847	41.2	58.2	59.9	49.6
3 Nov.	.79	.676	48.8	60.6	62.0	30.3
10 Nov.	1.87	.830	43.9	60.0	62.6	39.0
17 Nov.	.40	.871	41.3	58.9	61.3	41.7
24 Nov.	.32	1.086	48.2	65.7	66.6	48.6
1 Dec.	.76	1.085	44.7	63.1	65.7	50.5
8 Dec.	.10	.998	41.5	63.3	65.6	54.0
15 Dec.	2.33	1.055	47.4	65.2	66.9	29.0
22 Dec.	1.70	1.013	47.5	63.2	64.9	36.9
29 Dec.	1.69	1.261	48.5	65.8	68.1	52.5
1957						
5 Jan.	3.18	.748	46.9	62.7	65.4	31.7
12 Jan.	.28	1.256	47.8	64.9	67.1	61.9
19 Jan.	-	1.478	42.6	69.1	70.5	82.8
26 Jan.	.03	1.397	43.1	69.5	71.1	82.1
2 Feb.	-	1.559	51.3	72.3	73.2	67.9
9 Feb.	.50	1.475	52.3	69.8	72.0	48.2
16 Feb.	-	1.395	44.9	68.7	70.7	79.1
23 Feb.	.58	1.089	51.5	68.4	70.3	28.6
2 Mar.	.83	.933	42.5	64.0	67.7	59.3
9 Mar.	.47	1.004	48.5	60.5	69.7	42.4
16 Mar.	.40	.765	52.6	65.8	68.2	40.6
23 Mar.	1.70	.804	44.9	62.7	66.4	38.8



Appendix 2

Appendix 2

Plot (whole plant) and Component-Part Green Matter Weights of each Treatment Type of Marrow-Stem Kale at each Sampling Date

(Three 12-foot samples at each sampling date except first and last, when four and two samples per plot respectively.)(All weights are expressed in pounds)

Treatments \ Blocks	Total				Upper Leaf				Lower Leaf				Upper Stem				Lower Stem			
	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV
		Jan. 11				Jan. 11				Jan. 11				Jan. 11				Jan. 11		
Unthinned	37.25	43.00	42.25	51.00	13.50	13.00	14.50	16.50	1.75	2.00	1.50	1.00	11.00	14.00	12.25	16.50	11.00	14.00	14.00	17.00
	49.00	42.75	46.75	45.50	15.50	14.25	15.00	15.50	1.50	2.00	1.25	1.50	16.00	13.50	14.00	13.50	16.00	13.00	16.50	15.00
	52.00	28.25	28.75	45.75	16.50	10.00	11.50	15.75	0.50	2.25	1.25	1.50	18.50	7.50	7.50	13.00	16.50	8.50	8.50	15.50
	43.50	55.25	35.00	59.00	13.50	17.00	12.00	18.00	1.00	2.75	2.00	0.50	13.00	18.50	9.00	17.50	16.00	17.00	12.00	23.00
6" thinned	29.00	52.50	30.75	52.75	9.50	16.50	10.25	15.25	2.00	6.50	2.50	4.50	7.50	12.75	7.50	13.50	10.00	16.75	11.50	19.50
	30.50	61.50	40.00	46.25	10.00	21.50	14.50	14.50	2.00	4.00	3.00	2.75	7.50	17.00	10.00	13.00	11.00	19.00	12.50	16.00
	36.00	39.00	50.25	47.75	12.00	12.50	16.75	14.50	5.00	2.50	3.50	4.00	7.50	11.50	13.50	11.75	11.50	12.50	16.50	17.50
	36.50	40.00	39.00	49.00	11.50	15.50	13.50	16.25	2.75	2.50	4.00	2.50	9.50	10.00	10.00	12.75	12.75	12.00	13.50	17.50
12" thinned	54.75	45.00	40.75	41.25	21.50	16.00	13.50	15.50	6.00	5.50	2.50	3.75	14.25	11.00	11.00	10.00	16.00	12.50	13.75	12.00
	41.25	41.25	48.50	46.75	15.25	16.00	16.50	17.00	4.50	5.25	4.50	6.00	9.50	9.00	12.00	10.50	12.00	11.00	15.50	13.25
	54.00	49.00	42.25	40.00	20.25	19.00	13.50	14.00	6.00	3.50	66.50	3.50	12.25	12.75	9.00	9.75	15.50	13.75	13.25	12.75
	35.50	40.75	37.75	44.50	13.00	16.75	12.50	14.00	3.00	2.75	4.50	5.00	9.00	9.75	9.00	10.50	10.50	11.50	11.75	15.00
		Jan. 21				Jan. 21				Jan. 21				Jan. 21				Jan. 21		
Unthinned	53.50	42.75	41.75	38.25	17.00	15.50	13.50	12.00	0.50	0.75	0.75	0.25	18.50	13.00	13.00	12.50	17.50	13.50	14.50	13.50
	52.50	42.75	35.75	58.25	15.50	12.50	11.50	15.50	0.50	0.25	0.25	0.25	16.75	14.00	10.50	21.50	19.75	16.00	13.50	22.00
	49.75	51.75	41.50	62.00	14.50	14.50	13.50	18.75	0.25	0.25	0.50	1.25	15.50	17.00	12.50	19.50	19.00	20.00	15.50	22.50
6" thinned	37.50	48.50	49.25	43.25	11.50	17.50	16.00	12.50	1.00	1.50	0.50	2.00	11.50	13.00	14.50	11.75	15.50	16.50	18.25	17.00
	47.75	42.25	37.25	45.50	15.50	12.50	12.50	13.50	1.75	0.75	0.75	1.50	13.00	12.50	11.50	13.50	17.50	16.50	13.50	17.00
	50.00	48.50	32.25	50.00	17.50	16.00	11.50	16.00	2.50	3.00	1.00	2.50	13.50	13.00	8.25	13.75	16.50	16.50	12.00	17.75
12" thinned	54.50	62.50	43.00	31.50	17.00	19.50	14.50	11.00	0.50	5.50	2.50	1.50	18.50	16.50	10.50	8.50	17.50	21.00	15.50	11.50
	50.00	47.75	43.75	49.25	15.50	16.50	14.75	16.00	0.50	1.75	1.25	3.50	16.75	13.00	12.25	12.50	19.80	16.50	15.50	17.25
	44.50	41.50	48.25	36.25	14.50	14.50	16.00	12.50	0.25	0.50	2.25	2.50	16.00	12.50	13.00	9.50	19.00	14.00	17.00	11.75
		Jan. 31				Jan. 31				Jan. 31				Jan. 31				Jan. 31		
Unthinned	50.00	39.50	39.25	67.25	15.50	13.00	12.00	19.50	2.25	0.50	0.25	0.25	13.75	11.50	10.50	24.00	18.50	14.50	12.50	23.50
	61.25	39.50	43.00	48.50	18.00	12.00	12.25	15.75	2.00	0.25	0.25	0.50	18.50	12.00	13.00	15.25	22.75	15.25	17.50	17.00
	43.25	58.50	44.50	52.00	12.75	14.00	15.50	13.75	0.50	0.25	0.50	0.25	12.00	20.50	14.50	18.50	18.00	23.75	14.00	19.50
6" thinned	35.75	54.50	48.50	47.00	11.00	16.00	14.00	13.25	0.50	1.25	0.75	-	11.25	16.00	15.00	14.00	13.00	21.25	18.75	19.75
	47.50	48.25	43.75	53.50	14.00	13.00	14.50	14.25	1.00	1.25	0.25	0.25	14.00	14.50	12.75	17.25	18.50	19.50	16.25	21.75
	40.75	49.00	50.75	47.25	13.25	13.25	16.50	14.50	0.75	1.00	0.25	-	12.00	15.00	16.00	15.50	14.75	19.75	18.00	17.25
12" thinned	56.25	46.75	43.00	47.25	17.50	15.75	15.50	14.50	0.75	1.50	0.50	0.25	19.50	12.75	12.00	15.00	18.50	16.75	15.00	17.50
	53.25	43.50	47.50	51.50	15.00	12.50	14.75	15.50	0.50	0.50	1.50	1.50	18.00	12.50	14.50	15.50	19.75	18.00	18.00	19.00
	44.25	52.25	48.75	54.25	11.50	18.75	15.00	18.00	0.25	3.00	0.50	1.50	15.25	13.50	14.75	16.00	17.25	17.00	18.50	18.75

(contd.)

Appendix 2 (contd.)

Appendix 2 (contd.)

Treatments \ Blocks	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV
	Total				Upper Leaf				Lower Leaf				Upper Stem				Lower Stem			
	Feb. 10				Feb. 10				Feb. 10				Feb. 10				Feb. 10			
Unthinned	52.00	55.25	44.75	63.25	14.00	14.00	12.50	19.25	-	-	0.25	-	18.50	19.50	15.00	19.50	19.50	21.75	17.00	24.50
	62.50	55.20	38.50	61.50	17.00	13.00	12.00	14.00	-	0.25	0.50	-	22.00	19.75	12.00	24.25	23.50	22.50	14.00	23.25
	44.25	47.00	43.50	46.25	13.50	15.00	15.00	12.75	0.25	0.25	0.25	-	15.00	14.50	14.25	16.50	16.50	17.25	14.00	17.00
6" thinned	53.75	56.75	61.00	51.75	14.00	14.50	15.75	11.50	0.25	0.25	0.25	0.25	17.00	18.25	21.50	18.00	22.50	23.75	23.50	22.00
	47.00	45.00	43.00	56.25	13.00	12.25	12.00	14.50	0.25	0.50	-	0.25	15.25	14.75	14.50	19.50	18.50	17.50	16.50	22.00
	43.00	58.00	52.25	54.50	13.00	18.00	14.50	12.50	1.00	1.50	0.75	0.50	14.25	17.50	17.50	18.00	14.75	21.00	19.50	23.50
12" thinned	43.25	46.00	44.75	39.00	12.50	13.50	14.75	12.25	0.75	1.00	0.75	0.25	12.50	14.00	12.75	12.50	17.50	17.50	16.50	14.00
	66.00	44.50	52.75	49.50	22.00	12.50	16.75	13.50	0.50	0.50	0.50	0.50	21.00	14.00	16.50	15.50	22.50	17.50	19.00	20.00
	54.50	47.00	57.75	54.00	16.00	12.75	17.50	19.00	1.25	0.25	2.25	1.00	16.50	15.00	17.00	15.50	20.75	19.00	21.00	18.50
	Feb. 20				Feb. 20				Feb. 20				Feb. 20				Feb. 20			
Unthinned	54.75	49.75	50.25	69.00	12.00	10.75	14.00	14.00	0.25	-	0.25	0.50	21.00	18.50	18.00	27.50	21.50	20.50	18.00	27.00
	58.75	47.00	43.25	40.50	14.50	11.00	11.00	9.50	0.25	-	0.25	0.50	22.50	17.00	15.50	14.50	21.50	19.00	16.50	16.00
	66.25	55.00	56.00	59.50	18.25	15.50	13.50	11.50	-	-	-	-	25.50	19.50	21.50	24.50	22.50	20.00	21.00	23.50
6" thinned	48.25	55.50	56.25	66.25	10.50	14.50	14.00	14.50	-	1.00	-	0.25	17.50	18.50	19.50	25.00	20.25	21.50	22.75	26.50
	66.50	47.00	45.75	50.50	15.75	10.00	11.00	10.50	1.50	-	0.75	-	24.25	17.00	15.50	18.50	25.00	20.00	18.50	21.50
	58.00	52.50	41.75	58.00	13.75	13.00	10.00	14.00	0.25	-	0.25	-	21.50	18.50	14.50	19.50	22.50	21.00	17.00	24.50
12" thinned	53.00	69.75	52.50	46.50	14.50	21.50	13.50	12.75	1.00	0.50	-	-	16.00	22.75	18.00	15.50	21.50	25.00	21.00	18.25
	53.75	49.50	51.00	62.00	15.00	13.00	12.00	18.50	0.25	-	-	1.50	19.00	14.00	18.00	20.50	19.50	22.50	21.00	21.50
	56.00	47.75	59.25	46.75	12.50	10.75	14.50	11.00	-	0.50	0.25	0.25	20.50	16.50	21.50	15.50	23.00	20.00	23.00	20.00
	Mar. 2				Mar. 2				Mar. 2				Mar. 2				Mar. 2			
Unthinned	59.00	67.00	41.00	68.50	13.00	15.50	10.00	17.00	-	-	-	-	24.00	25.00	15.00	27.00	22.00	26.50	16.00	24.50
	68.50	59.75	52.50	60.75	16.00	13.50	14.00	13.50	-	-	-	-	27.50	24.50	20.50	24.25	25.00	21.75	18.00	23.00
	72.50	79.50	45.50	81.50	17.50	20.50	10.75	21.50	-	-	-	-	29.50	31.00	15.75	32.50	25.50	28.00	19.00	27.50
6" thinned	62.50	75.50	52.50	56.50	14.50	20.00	12.50	13.00	-	-	-	-	23.00	29.50	18.50	20.50	25.00	26.00	21.50	23.00
	62.00	62.50	45.00	54.50	14.00	15.00	13.00	12.50	-	-	-	-	23.00	21.50	15.00	20.00	25.00	26.00	17.00	22.00
	43.50	54.50	66.50	58.75	12.50	13.75	15.00	14.00	-	-	-	-	15.50	18.75	23.50	21.00	15.50	22.00	28.00	23.75
12" thinned	54.00	60.50	54.00	67.00	13.00	14.50	10.50	18.25	-	0.25	-	-	19.50	21.25	21.00	23.25	21.50	24.50	22.50	25.50
	55.00	60.75	51.50	66.00	13.00	19.75	14.00	13.50	-	0.25	-	-	19.50	20.25	18.00	25.50	22.50	20.50	19.50	27.00
	63.00	79.25	60.00	57.00	16.50	23.50	15.75	11.50	-	0.50	-	-	22.50	28.25	21.75	20.00	24.00	27.00	22.50	25.50

(contd.)

Appendix 2 (contd.)

Appendix 2 (contd.)

Treatments \ Blocks	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV
	Total				Upper Leaf				Lower Leaf				Upper Stem				Lower Stem			
	Mar. 12				Mar. 12				Mar. 12				Mar. 12				Mar. 12			
Unthinned	83.00	66.00	52.00	59.00	22.50	18.50	12.00	13.00	-	-	-	-	33.00	25.00	21.50	23.00	27.50	22.50	18.50	23.00
	62.00	59.00	48.00	80.50	13.50	15.00	12.50	17.50	-	-	-	-	24.50	23.00	18.50	32.50	24.00	21.00	17.00	30.50
	70.50	60.50	58.75	79.50	15.50	13.50	15.50	16.00	-	-	-	-	29.50	23.50	22.75	32.00	25.50	23.50	20.50	31.50
6" thinned	56.00	87.50	72.50	58.50	13.00	20.00	17.00	12.50	-	-	-	-	20.50	35.00	28.50	20.50	22.50	32.50	27.00	25.50
	90.50	72.50	60.00	68.00	20.00	18.50	14.50	14.50	-	-	-	-	34.50	27.00	22.50	26.00	36.00	27.00	23.00	27.50
	47.00	81.00	53.00	70.00	11.00	17.00	14.00	15.00	-	-	-	-	17.50	32.50	18.50	25.50	18.50	31.50	20.50	29.50
12" thinned	82.50	73.00	64.25	71.75	22.50	20.50	17.00	17.00	-	1.00	0.25	-	30.00	24.50	22.50	27.50	30.00	27.00	24.50	27.25
	49.25	76.50	73.75	69.25	12.50	23.00	19.00	13.50	-	-	-	-	16.75	29.00	25.50	32.25	20.00	24.50	29.25	23.50
	59.50	46.25	46.50	46.00	19.00	11.50	12.75	10.50	-	0.25	0.25	-	19.50	15.50	15.50	18.00	21.00	19.00	18.00	17.50
		Mar. 22				Mar. 22				Mar. 22				Mar. 22				Mar. 22		
Unthinned	64.50	64.50	75.00	71.50	13.50	15.50	18.00	14.50	-	-	-	-	25.50	24.50	29.50	29.50	25.50	24.50	27.50	27.50
	82.00	60.00	59.50	60.00	18.50	15.50	14.50	13.50	-	-	-	-	33.00	23.50	22.50	22.00	30.50	21.00	22.50	24.50
6" thinned	69.00	64.00	62.00	83.50	14.50	13.50	13.50	17.50	-	-	-	-	26.00	23.50	23.00	33.00	28.50	27.00	25.50	33.00
	75.00	72.00	67.00	53.75	15.50	14.50	14.50	10.25	-	-	-	-	30.50	28.50	25.50	20.50	29.00	29.00	27.00	23.00
12" thinned	89.50	82.50	59.00	62.50	19.50	20.50	11.50	14.00	-	-	-	-	34.50	29.50	22.50	24.00	35.50	32.50	25.00	24.50
	78.50	61.00	72.50	59.50	16.50	15.00	16.50	10.50	-	-	-	-	28.50	22.50	27.50	22.00	33.50	23.50	28.50	27.00

Appendix 3

Appendix 3

Analyses of Variance for Plot (whole plant), Component-Part and Total-Leaf Sample Green Matter Yields over all Sampling Dates

Source of Variation	d.f.	F value reqd.		Whole Plant			Upper Leaf			Total Leaf			Upper Stem			Lower Stem		
		.05	.01	M.s.	F	Result	M.s.	F	Result	M.s.	F	Result	M.s.	F	Result	M.s.	F	Result
Blocks	3	4.76	9.78	201.89	1.86	N.S.	10.36	1.62	N.S.	11.90	2.55	N.S.	33.31	2.03	N.S.	32.42	1.87	N.S.
Treatments	2	5.14	10.92	5.29	0.05	N.S.	13.85	2.16	N.S.	35.99	7.71	*	42.21	2.57	N.S.	5.98	0.35	N.S.
Blocks x Treatments	6			108.32			6.40			4.67			16.42			17.32		
Dates	7	2.15	2.93	1028.97	55.86	**	6.48	3.45	**	18.69	6.31	**	325.96	90.54	**	231.32	90.36	**
Regression	1	3.99	7.04	6996.30	379.82	**							2243.27	623.13	**	1608.93	62849	**
Deviation	6	2.24	3.09	34.41	1.87	N.S.							6.41	1.78	N.S.	1.71	0.67	N.S.
Dates x Treatments	14	1.85	2.37	11.19	0.61	N.S.	0.35	0.19	N.S.	2.04	0.69	N.S.	3.31	0.92	N.S.	4.12	1.61	N.S.
Residual	63			18.42			1.88			2.96			3.60			2.56		
Total	95																	

Appendix 4.

Appendix 4

Summed Plot and Component-Part Dry Matter Weights of each Treatment Type of Marrow-stem Kale at each Sampling Date

(Sum of three x 12-foot samples per plot at each sampling date, except first and last when sum of four and two x 12-foot samples per plot respectively)
(All weights expressed in pounds - moisture free basis)

Treatments \ Blocks	Total I	Total II	Total III	Total IV	Upper Leaf I	Upper Leaf II	Upper Leaf III	Upper Leaf IV	Lower Leaf I	Lower Leaf II	Lower Leaf III	Lower Leaf IV	Upper Stem I	Upper Stem II	Upper Stem III	Upper Stem IV	Lower Stem I	Lower Stem II	Lower Stem III	Lower Stem IV
		Jan. 11				Jan. 11				Jan. 11				Jan. 11				Jan. 11		
Unthinned	20.24	16.84	18.10	20.11	7.69	6.14	6.80	6.86	0.63	0.81	0.67	0.43	5.18	4.11	3.92	4.94	6.74	5.78	6.71	7.88
6" thinned	13.82	22.12	18.37	21.79	5.58	8.69	7.16	8.17	1.31	1.44	1.39	1.44	2.52	3.85	3.61	4.20	4.41	8.14	6.21	7.98
12" thinned	18.95	17.31	17.80	18.13	8.20	7.91	7.09	7.57	1.82	1.65	1.79	1.79	3.38	3.20	3.36	3.46	5.55	4.55	5.56	5.31
		Jan. 21				Jan.21				Jan. 21				Jan. 21				Jan. 21		
Unthinned	18.50	15.57	13.98	19.27	6.00	5.33	5.42	6.17	0.15	0.15	0.20	0.20	4.61	5.02	3.43	5.26	7.74	5.07	4.93	7.64
6" thinned	16.50	16.27	13.28	17.36	6.15	6.75	5.70	5.64	0.55	0.63	0.27	0.72	3.57	3.70	2.71	3.58	6.23	5.19	4.60	7.42
12" thinned	16.44	19.47	14.00	13.68	6.50	7.59	6.11	5.70	0.13	0.84	0.56	0.78	4.23	4.17	2.65	2.85	5.58	6.87	4.68	4.35
		Jan. 31				Jan. 31				Jan. 31				Jan. 31				Jan. 31		
Unthinned	18.18	14.61	14.83	21.06	6.32	5.13	5.49	6.53	0.50	0.15	0.11	0.12	3.76	4.07	3.54	6.06	7.60	5.26	5.69	8.35
6" thinned	14.83	16.51	19.97	17.98	5.52	5.42	6.45	5.84	0.25	0.36	0.15	0.03	4.01	4.67	4.63	5.22	5.05	6.06	8.74	8.92
12" thinned	17.55	16.28	15.57	18.80	6.31	6.47	6.79	6.60	0.20	0.53	0.13	0.39	4.66	3.19	3.33	4.03	6.38	6.09	5.32	7.78
		Feb. 10				Feb. 10				Feb. 10				Feb. 10				Feb. 10		
Unthinned	20.39	20.16	17.98	19.42	7.02	5.99	5.79	6.40	0.03	0.06	0.12	-	5.65	5.55	5.06	5.52	8.69	8.56	7.01	7.50
6" thinned	16.50	17.89	19.15	19.92	6.06	5.93	6.34	5.58	0.18	0.26	0.13	0.09	3.84	4.38	5.62	5.14	6.42	7.32	7.06	9.11
12" thinned	18.32	14.66	16.96	17.90	7.16	5.26	6.65	6.82	0.30	0.25	0.43	0.20	4.33	4.02	3.85	4.97	6.53	5.13	6.03	5.91
		Feb. 20				Feb. 20				Feb. 20				Feb. 20				Feb. 20		
Unthinned	22.32	20.68	20.22	22.79	6.86	6.03	5.14	5.37	0.06	-	0.08	0.14	6.78	5.82	8.34	7.09	8.62	8.83	6.66	10.91
6" thinned	18.92	17.85	16.56	19.40	5.73	4.76	5.08	5.33	0.22	0.16	0.15	0.04	5.17	5.22	5.03	6.30	7.80	7.71	6.30	7.73
12" thinned	18.12	19.49	20.19	22.31	5.88	6.11	5.93	6.48	0.15	0.10	0.03	0.26	4.62	4.61	5.56	5.41	7.47	8.67	8.67	10.16
		Mar. 2				Mar. 2				Mar. 2				Mar. 2				Mar. 2		
Unthinned	24.44	23.10	20.43	29.09	6.19	6.45	5.39	8.15	-	-	-	-	8.10	9.40	7.00	8.94	10.15	7.25	8.04	12.00
6" thinned	18.04	24.61	19.52	24.16	5.74	6.91	5.64	5.59	-	-	-	-	5.75	6.85	5.23	7.69	6.55	10.85	8.65	10.88
12" thinned	20.95	20.15	18.27	22.34	5.82	7.32	5.37	5.48	-	-	-	-	4.92	5.11	5.27	6.07	10.21	7.68	7.63	10.79
		Mar. 12				Mar. 12				Mar. 12				Mar. 12				Mar. 12		
Unthinned	27.86	23.61	21.85	24.11	7.12	6.20	5.47	6.75	-	-	-	-	8.55	6.91	8.17	8.60	12.19	10.50	8.21	8.78
6" thinned	21.59	24.22	23.07	25.26	5.13	6.47	6.37	6.52	-	-	-	-	6.29	8.04	7.41	8.16	10.27	9.71	9.29	10.58
12" thinned	19.50	23.87	25.60	21.97	7.83	7.63	6.59	6.01	-	0.17	0.06	-	5.63	6.78	6.88	8.56	6.04	9.29	12.07	7.40
		Mar.22				Mar.22				Mar.22				Mar. 22				Mar. 22		
Unthinned	20.15	14.43	21.34	19.85	4.74	3.88	4.60	4.21	-	-	-	-	6.54	4.33	8.23	6.79	8.87	6.22	8.51	8.85
6" thinned	14.96	18.55	15.87	18.20	3.45	4.25	3.78	3.93	-	-	-	-	5.28	5.80	5.17	6.33	6.23	8.50	6.92	7.94
12" thinned	17.33	16.35	16.88	16.86	4.73	4.32	3.87	3.39	-	-	-	-	5.35	5.03	5.16	4.45	7.25	7.00	7.85	9.02

Appendix 5

Appendix 5

Analyses of Variance for Plot (whole plant), Component-Part and Total-Leaf Sample Dry Matter Yields over all Sampling Dates

Source of Variation	d.f.	F value reqd.		Whole Plant			Upper Leaf			Total Leaf			Upper Stem			Lower Stem		
		.05	.01	M.s.	F	Result	M.s.	F	Result	M.s.	F	Result	M.s.	F	Result	M.s.	F	Result
Blocks	3	4.76	9.78	2.44	1.43	N.S.	0.07	0.47	N.S.	0.08	0.53	N.S.	0.33	3.30	N.S.	0.95	1.90	N.S.
Treatments	2	5.14	10.92	2.75	1.61	N.S.	0.22	1.47	N.S.	0.35	2.33	N.S.	2.16	21.60	**	0.56	1.12	N.S.
Regression	1	5.99	13.74										4.23	42.30	**			
Deviation	1	5.99	13.74										0.09	0.90	N.S.			
Blocks x Treatments	6			1.71			0.15			0.15			0.10			0.50		
Dates	7	2.15	2.93	22.86	50.80	**	0.13	3.25	**	0.07	1.75	N.S.	5.08	63.50	**	6.67	39.24	**
Regression	1	3.99	7.04	157.79	350.04	**							35.14	439.25	**	45.42	267.18	**
Deviation	6	2.24	3.09	0.38	0.84	N.S.							0.07	0.88	N.S.	0.22	1.29	N.S.
Dates x Treatments	14	1.85	2.37	0.37	0.82	N.S.	0.04	1.00	N.S.	0107	1.75	N.S.	0.10	1.25	N.S.	0.13	0.76	N.S.
Residual	63			0.45			0.04			0.04			0.08			0.17		
Total	95																	

Appendix 6

Appendix 6

Leaf Percentages (green matter basis) for each Plot Sample of each Treatment
Type of Marrow-stem Kale at each Sampling Date

Treatments \ Blocks	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV
	Jan. 11				Jan. 21				Jan. 31				Feb. 10			
Unthinned	40.9 34.7 32.7 33.3	34.9 38.0 43.4 35.8	37.9 34.8 44.4 40.0	34.3 37.4 37.7 31.4	32.1 30.5 29.7	38.0 29.8 28.5	34.1 32.9 33.7	32.0 27.0 32.3	35.5 32.7 30.6	34.2 31.0 24.4	34.8 29.1 36.0	29.4 33.5 26.9	26.9 27.2 31.1	25.3 23.9 32.5	28.5 32.5 35.1	30.4 22.8 27.6
6" thinned	39.7 39.3 47.2 39.0	43.8 41.5 38.5 45.0	41.5 43.8 40.3 39.7	37.4 37.8 38.7 38.3	33.3 36.1 40.0	39.2 31.4 39.2	33.5 35.1 38.8	33.5 33.0 37.0	32.2 31.6 34.4	31.7 29.5 29.1	30.4 33.7 33.0	28.2 27.1 30.7	26.5 28.2 32.6	26.0 28.3 33.6	26.2 27.9 29.2	22.7 26.2 23.9
12" thinned	47.6 47.9 48.6 45.1	47.8 51.5 45.9 47.9	39.3 43.3 47.3 45.0	46.7 49.2 43.8 42.7	32.1 32.0 33.2	40.0 38.2 36.1	39.5 36.6 37.8	39.7 39.6 41.4	32.4 29.1 26.6	36.9 29.9 41.6	37.2 31.6 31.8	31.2 33.0 35.9	30.6 34.1 31.7	31.5 29.2 27.7	34.6 32.7 34.2	32.1 28.3 37.0
	Feb. 20				Mar. 2				Mar. 12				Mar. 22			
Unthinned	22.4 25.1 27.6	21.6 23.4 28.2	28.4 26.0 24.1	21.0 24.7 19.3	22.0 23.4 24.1	23.1 22.6 25.8	24.4 26.7 23.6	24.8 22.2 26.4	27.1 21.8 22.0	28.0 25.4 22.3	23.1 26.0 26.4	22.0 21.7 20.1	20.9 22.6	24.0 25.8	24.0 24.4	20.3 22.5
6" thinned	21.8 25.9 24.1	27.9 21.3 24.8	24.9 25.7 24.6	22.3 20.8 24.1	23.2 22.6 28.7	26.5 24.0 25.2	23.8 28.9 22.6	23.0 22.9 23.8	23.2 22.1 23.4	22.9 25.5 21.0	23.5 24.2 26.4	21.4 21.2 21.4	21.0 20.7	21.1 20.1	21.8 21.6	21.0 19.1
12" thinned	29.3 28.4 22.3	31.5 26.3 23.6	25.7 23.5 24.9	27.4 32.3 24.1	24.1 23.6 26.2	24.4 32.9 30.3	19.4 27.2 26.3	27.2 20.5 20.2	27.3 25.4 31.9	29.5 30.1 25.4	26.9 25.8 28.0	23.7 19.5 22.8	21.8 21.0	24.9 24.6	19.5 22.8	22.4 17.7

Appendix 7

Analyses of Variance for Leaf Percentages on (a) Green Matter Basis (b) Dry Matter Basis over all Sampling Dates

Source of Variation	d.f.	F value reqd.		Leaf % - green			Leaf % - dry		
		.05	.01	M.s.	F	Result	M.s.	F	Result
Blocks	3	4.76	9.78	24.06	3.38	N.S.	34.18	6.25	*
Treatments	2	5.14	10.92	85.78	12.06	**	218.42	39.93	**
Regression	1	5.99	13.74	146.11	20.55	**	432.12	79.00	**
Deviation	1	5.99	13.74	25.44	3.58	N.S.	4.71	0.86	N.S.
Blocks x Treatments	6			7.11			5.47		
Dates	7	2.15	2.93	517.94	42.91	**	698.25	85.26	**
Regression	1	3.99	7.04	3396.92	1321.76	**	4635.24	565.96	**
Deviation	6	2.24	3.09	54.78	21.32	**	42.08	5.14	**
Dates x Treatments	14	1.85	2.37	12.07	4.70	**	17.07	2.08	*
Residual	63			2.57			8.19		
Total	95								

Appendix 8

Leaf Percentages (dry matter basis) for each Summed Plot Sample of each Treatment Type of Marrow-stem Kale at each Sampling Date

Blocks / Treatments	I	II	III	IV
	Jan. 11			
Unthinned	41.4	41.8	41.9	36.5
6" thinned	46.8	45.8	46.5	44.1
12" thinned	52.7	55.3	49.9	51.5
	Jan. 21			
Unthinned	33.2	35.5	40.2	33.3
6" thinned	40.3	45.1	45.2	36.5
12" thinned	40.3	43.1	47.7	47.4
	Jan. 31			
Unthinned	37.4	36.9	37.8	31.7
6" thinned	39.0	34.9	33.1	34.3
12" thinned	36.8	42.6	33.6	37.1
	Feb. 10			
Unthinned	34.7	31.2	32.9	32.9
6" thinned	38.1	34.5	33.9	38.4
12" thinned	40.4	37.6	41.8	39.1
	Feb. 20			
Unthinned	30.8	29.0	25.9	24.5
6" thinned	31.2	27.3	31.6	27.6
12" thinned	33.3	31.2	29.5	29.8
	Mar. 2			
Unthinned	25.2	27.7	26.3	27.8
6" thinned	32.3	28.0	29.3	23.1
12" thinned	27.7	36.7	29.3	24.4
	Mar. 12			
Unthinned	25.3	26.2	25.0	28.1
6" thinned	23.9	26.8	27.8	25.8
12" thinned	40.1	31.6	26.1	27.4
	Mar. 22			
Unthinned	23.4	26.9	21.6	21.3
6" thinned	23.1	22.9	23.8	21.4
12" thinned	27.3	26.4	22.8	20.1

Appendix 9

Appendix 9

Dry Matter Percentages of the Component Parts of each Treatment Type of Marrow-stem Kale at each Sampling Date

(moisture-free basis)

(a) Upper Leaf

Block No.	Treatment	Sampling Date Dry Matter Percentages							
		Jan.11	Jan.21	Jan.31	Feb.10	Feb.20	Mar.2	Mar.12	Mar.22
I	Ut	13.04	12.75	13.67	15.75	15.33	13.33	13.17	14.83
	St	12.96	13.83	14.42	15.17	14.33	14.00	11.67	11.50
	Tt	11.71	13.83	14.33	14.17	14.00	12.67	14.50	13.13
II	Ut	11.33	12.58	13.17	14.25	16.17	13.00	13.17	12.50
	St	13.17	14.67	12.83	13.25	12.67	14.17	14.00	15.17
	Tt	11.67	15.00	13.75	13.58	13.50	13.33	14.50	12.17
III	Ut	12.83	14.08	13.83	14.67	13.33	15.50	13.83	14.17
	St	13.00	14.25	14.33	15.00	14.50	13.92	11.67	13.50
	Tt	12.67	13.50	15.00	13.58	14.83	13.67	13.50	13.83
IV	Ut	10.42	13.33	13.33	13.92	15.33	15.67	14.50	15.00
	St	13.50	13.42	13.92	14.50	13.67	14.17	15.50	14.17
	Tt	12.50	14.42	13.75	15.75	15.33	12.67	14.67	13.82

(b) Lower Leaf

Block No.	Treatment	Sampling Date Dry Matter Percentages							
		Jan.11	Jan.21	Jan.31	Feb.10	Feb.20	Mar.2	Mar.12	Mar.22
I	Ut	13.22	11.25	10.58	12.59	12.83	-	-	-
	St	11.17	10.50	11.17	11.67	12.67	-	-	-
	Tt	9.33	10.00	13.25	12.00	11.83	10.00	-	-
II	Ut	9.00	11.33	13.00	12.67	-	-	-	-
	St	9.33	12.00	10.00	11.17	16.17	-	-	-
	Tt	9.17	10.92	10.67	13.67	10.67	-	13.50	-
III	Ut	11.00	12.92	10.83	12.50	14.33	-	-	-
	St	10.67	11.92	12.08	13.17	14.33	-	-	-
	Tt	9.92	9.33	9.83	12.33	12.33	-	13.00	-
IV	Ut	9.58	11.33	12.50	-	14.33	-	-	-
	St	10.50	12.00	11.33	9.17	14.17	-	-	-
	Tt	9.83	10.42	11.75	11.25	14.67	-	-	-

(c) Upper Stem

I	Ut	8.86	9.08	8.50	10.17	9.83	10.00	9.67	11.17
	St	7.88	9.42	10.75	8.25	8.17	9.33	8.50	9.33
	Tt	7.50	8.25	8.83	8.67	8.33	7.33	8.50	8.50
II	Ut	7.67	10.92	9.25	10.33	10.58	11.67	13.00	9.00
	St	7.50	9.58	10.25	8.67	9.67	9.83	10.67	11.17
	Tt	7.50	9.92	8.25	9.33	8.67	8.67	9.83	9.67
III	Ut	9.17	9.50	9.33	12.25	15.17	13.67	9.83	15.83
	St	8.83	7.92	10.58	10.50	10.17	9.17	8.67	10.67
	Tt	8.17	7.42	8.08	8.33	9.67	8.00	10.83	10.33
IV	Ut	8.17	9.83	10.50	9.17	10.67	10.67	9.83	13.17
	St	8.25	9.17	11.17	9.25	10.00	12.50	11.33	11.83
	Tt	8.50	9.33	8.67	11.42	10.50	8.83	11.00	9.67

(d) Lower Stem

I	Ut	11.13	13.75	12.83	12.92	13.17	14.00	15.67	15.83
	St	9.75	12.58	10.92	11.50	11.50	10.00	10.67	10.83
	Tt	10.29	9.92	11.50	10.75	11.67	10.67	8.50	10.50
II	Ut	11.00	10.25	9.83	13.92	14.83	9.50	14.67	13.67
	St	13.50	10.50	10.00	11.75	12.33	14.67	13.17	15.17
	Tt	9.33	13.33	11.75	9.50	12.83	11.83	13.17	12.50
III	Ut	13.17	11.33	12.92	15.58	12.00	15.17	15.83	17.00
	St	11.50	10.50	16.50	11.58	10.83	13.00	13.33	13.17
	Tt	10.25	9.75	10.33	10.67	13.33	15.00	16.83	14.67
IV	Ut	11.17	13.17	13.92	11.58	15.33	16.00	10.33	17.00
	St	11.33	14.33	15.17	13.50	10.67	15.83	12.83	14.17
	Tt	10.00	10.75	14.08	11.25	17.00	13.83	10.83	17.50

Appendix 10

Appendix 10

Analyses of Variance on the Dry Matter Percentages of the Component Parts of the Treatment Types of Marrow-stem Kale over all Sampling Dates

Source of Variation	d.f.	F value reqd.		Upper Leaf			Upper Stem			Lower Stem			d.f.	F Value		Lower Leaf		
		.05	.01	M.s.	F	Result	M.s.	F	Result	M.s.	F	Result		.05	.01	M.s.	F	Result
Blocks	3	4.76	9.78	1.40	3.33	N.S.	7.25	2.55	N.S.	14.65	2.82	N.S.	3	4.76	9.78	0.17	0.20	N.S.
Treatments	2	5.14	10.92	0.05	0.12	N.S.	19.82	6.98	*	16.15	3.11	N.S.	2	5.14	10.92	4.59	5.34	*
Regression	1	5.99	13.74				39.53	13.92	**				1	5.99	13.74	8.93	10.38	*
Deviation	1	5.99	13.74				0.11	0.04	N.S.				1	5.99	13.74	0.25	0.29	N.S.
Blocks x Treatments	6			0.42			2.84			5.19			6			0.86		
Dates	7	2.15	2.93	4.86	5.72	**	7.54	6.28	**	12.59	3.78	**	4	2.63	3.89	17.91	12.18	**
Regression	1	3.99	7.04				45.51	37.93	**	77.32	23.22	**	1	4.11	7.39	67.50	45.92	**
Deviation	6	2.24	3.09				1.21	1.01	N.S.	1.80	0.54	N.S.	3	2.86	4.38	1.37	0.93	N.S.
Dates x Treatments	14	1.85	2.37	1.27	1.49	N.S.	2.08	1.73	N.S.	2.71	0.81	N.S.	8	2.21	3.04	1.54	1.05	N.S.
Residual	63			0.85			1.20			3.33			36			1.47		
Total	95												59					

Appendix 11

Analysis of Covariance and Test of Significance of the Adjusted Mean Fresh Matter Intakes of Sheep fed Experimental Marrow-stem Kale

Source of Variation	d.f.	SSx	SSxy	SSy	Errors of Estimate			
					SSy_1	d.f.1	M.s.	F
Total	8	2934.52	4384.08	12143.06				
Blocks	2	713.53	1321.10	3079.53				
Treatments	2	509.94	540.73	3695.67				
Within treatments(error)	4	1711.05	2422.25	5367.86	1938.80	3	646.27	
Treatments + Error	6	2220.99	2962.98	9063.53	5110.68	5		
Treatments					3171.88	2	1585.94	2.45 N.S.

N.S. Not Significant ($p > 0.05$)
F required (.05, .01) = 9.55, 30.82

Analysis of Error Variance

Source of Variation	d.f.	SS	M.s.	F
Between Treatments - Unadjusted Intakes	4	5367.86	1341.99	
Reduction due to Regression	1	3429.06	3429.06	5.31 N.S.
Error for Adjusted Intakes	3	1938.80	646.27	

N.S. Not Significant ($p > 0.05$)
F required (.05, .01) = 10.13, 34.12

Appendix 12

Analysis of Covariance and Test of Significance of the Adjusted Mean Dry Matter Intakes of Sheep fed Experimental Marrow-stem Kale

Source of Variation	d.f.	SSx	SSxy	SSy	Errors of Estimate			
					SSy_1	d.f.1	M.s.	F
Total	8	32.83	46.48	101.35				
Blocks	2	7.62	14.65	33.27				
Treatments	2	7.18	5.06	10.44				
Within treatments(error)	4	18.03	26.77	57.64	17.89	3	5.96	
Treatments + Error	6	25.21	31.83	68.08	27.89	5		
Treatments					10.00	2	5.00	<1 N.S.

N.S. Not Significant ($p > 0.05$)
F required (.05, .01) = 9.55, 30.82

Analysis of Error Variance

Source of Variation	d.f.	SS	M.s.	F
Between Treatments Unadjusted Intakes	4	57.64	14.41	
Reduction due to Regression	1	39.75	39.75	6.67 N.S.
Error for Adjusted Intakes	3	17.89	5.96	

N.S. Not Significant ($p > 0.05$)
F required (.05, .01) = 10.13, 34.12

Appendix 13

Calculated Digestibilities of the Feed Constituents in the Three Types of Experimental Marrow-stem Kale (weights in grams obtained by pounds x 453.59)

(a) Digestibility of Dry Matter

Marrow-stem Kale	Sheep No.	Dry Matter Offered gms.	Dry Matter Refused gms.	Dry Matter Consumed gms.	Dry Matter Excreted gms.	Dry Matter Retained gms.	Percentage Digestibility of Dry Matter
Ut	2	13870.78	1319.95	12550.83	2629.13	9921.70	79.1
	4	13870.78	3283.99	10586.79	1743.24	8843.55	83.5
	9	13870.78	272.15	13598.63	2475.01	11123.62	81.8
St	1	14709.92	5982.95	8727.07	1407.74	7319.33	83.9
	6	14709.92	4027.88	10682.04	1893.06	8788.98	82.3
	8	14709.92	970.68	13739.24	2570.84	11168.40	81.3
Tt	3	14673.64	2140.94	12532.70	1936.95	10595.75	84.5
	5	14673.64	3542.54	11131.10	1863.41	9267.69	83.3
	7	14673.64	3492.64	11181.00	1856.25	9324.75	83.4

(b) Digestibility of Crude Protein

Marrow-stem Kale	Sheep No.	Crude Protein Offered gms.	Crude Protein Refused gms.	Crude Protein Consumed gms.	Crude Protein Excreted gms.	Crude Protein Retained gms.	Percentage Digestibility of Crude Protein
Ut	2	2084.78	124.08	1960.70	449.32	1511.38	77.1
	4	2084.78	482.42	1602.36	249.81	1352.55	84.4
	9	2084.78	26.48	2058.30	408.13	1650.17	80.2
St	1	2193.25	678.47	1514.78	176.11	1338.67	88.4
	6	2193.25	453.14	1740.11	295.70	1444.41	83.0
	8	2193.25	108.62	2084.63	376.37	1708.26	82.0
Tt	3	2157.03	220.95	1936.08	276.21	1659.87	85.7
	5	2157.03	377.63	1779.40	262.93	1516.47	85.2
	7	2157.03	390.83	1766.20	288.09	1478.11	83.7

(contd.)

Appendix 13 (contd.)

(c) Digestibility of Crude Fibre

Marrow-stem Kale	Sheep No.	Crude Fibre Offered gms.	Crude Fibre Refused gms.	Crude Fibre Consumed gms.	Crude Fibre Excreted gms.	Crude Fibre Retained gms.	Percentage Digestibility of Crude Fibre
Ut	2	2181.87	256.33	1925.54	294.99	1630.55	84.7
	4	2181.87	517.23	1664.64	201.34	1463.30	87.9
	9	2181.87	59.49	2122.38	326.45	1795.93	84.6
St	1	2291.81	1123.60	1168.21	134.16	1034.05	88.5
	6	2291.81	847.47	1444.34	186.85	1257.49	87.1
	8	2291.81	248.11	2043.70	330.10	1713.60	83.9
Tt	3	2281.75	511.68	1770.07	232.43	1537.64	86.9
	5	2281.75	775.46	1506.29	230.88	1275.41	84.7
	7	2281.75	808.55	1473.20	230.92	1242.28	84.3

(d) Digestibility of Ether Extract

Marrow-stem Kale	Sheep No.	Ether Extract Offered gms.	Ether Extract Refused gms.	Ether Extract Consumed gms.	Ether Extract Excreted gms.	Ether Extract Retained gms.	Percentage Digestibility of Ether Extract
Ut	2	380.06	13.46	366.60	253.19	113.41	30.9
	4	380.06	72.25	307.81	195.94	111.87	36.3
	9	380.06	3.81	376.25	234.14	142.11	37.8
St	1	403.05	57.44	345.61	186.53	159.08	46.0
	6	403.05	32.22	370.83	221.49	149.34	40.3
	8	403.05	12.13	390.92	250.40	140.52	36.0
Tt	3	384.45	24.83	359.62	184.79	174.83	48.6
	5	384.45	40.38	344.07	191.74	152.33	44.3
	7	384.45	50.99	333.46	219.04	114.42	34.3

(contd.)

Appendix 13 (contd.)

(e) Digestibility of Nitrogen-free Extract (NFE)

Marrow-stem Kale	Sheep No.	NFE Offered gms.	NFE Refused gms.	NFE Consumed gms.	NFE Excreted gms.	NFE Retained gms.	Percentage Digestibility of NFE
Ut	2	7264.13	767.15	6496.98	751.67	5745.31	88.4
	4	7264.13	1756.93	5507.20	506.76	5000.44	90.8
	9	7264.13	149.14	7114.99	808.83	6306.16	88.6
St	1	7794.79	3361.82	4432.97	323.08	4109.89	93.0
	6	7794.79	2201.24	5593.55	536.11	5057.44	90.7
	8	7794.79	491.36	7303.43	850.69	6452.74	88.6
Tt	3	8071.97	1136.20	6935.77	497.99	6437.78	92.8
	5	8071.97	1915.10	6156.87	589.40	5567.47	90.4
	7	8071.97	1802.20	6269.77	395.75	5874.02	93.7

(f) Digestibility of Organic Matter

Marrow-stem Kale	Sheep No.	Organic Matter Offered gms.	Organic Matter Refused gms.	Organic Matter Consumed gms.	Organic Matter Excreted gms.	Organic Matter Retained gms.	Percentage Digestibility of Organic Matter
Ut	2	11910.84	1161.03	10749.81	1749.16	9000.65	83.7
	4	11910.84	2828.83	9082.01	1153.85	7928.16	87.3
	9	11910.84	238.92	11671.92	1777.55	9894.37	84.8
St	1	12682.89	5221.32	7461.57	819.87	6641.70	89.0
	6	12682.89	3534.06	9148.83	1240.14	7908.69	86.4
	8	12682.89	860.22	11822.67	1807.56	10015.11	84.7
Tt	3	12895.19	1893.66	11001.53	1191.42	9810.11	89.2
	5	12895.19	3108.58	9786.61	1274.95	8511.66	87.0
	7	12895.19	3052.57	9842.62	1133.80	8708.82	88.5

Appendix 14

Analyses of Variance of the Feed Constituent Apparent Digestion Coefficients of the Three Types of Experimental Marrow-stem Kale

Source of Variation	d.f.	F required .05	F required .01	Dry Matter M.s.	Dry Matter F	Dry Matter Result	Crude Protein M.s.	Crude Protein F	Crude Protein Result	Crude Fibre M.s.	Crude Fibre F	Crude Fibre Result
Blocks	2	6.94	18.00	.58	.18	N.S.	4.31	.71	N.S.	5.54	1.98	N.S.
Treatments	2	6.94	18.00	3.90	1.18	N.S.	17.02	2.79	N.S.	1.08	.39	N.S.
Residual	4			3.31			6.10			2.80		
Total	8											
Treatment Means and Standard Errors: Unthinned				81.5 ± 1.1			80.6 ± 1.4			85.7 ± 1.0		
6" thinned				82.5 ± 1.1			84.4 ± 1.4			86.5 ± 1.0		
12" thinned				83.7 ± 1.1			84.9 ± 1.4			85.3 ± 1.0		

Source of Variation	d.f.	F required .05	F required .01	Ether Extract M.s.	Ether Extract F	Ether Extract Result	Nitrogen-free-Extract M.s.	Nitrogen-free-Extract F	Nitrogen-free-Extract Result	Organic Matter M.s.	Organic Matter F	Organic Matter Result
Blocks	2	6.94	18.00	27.54	.85	N.S.	.95	.23	N.S.	1.37	.34	N.S.
Treatments	2	6.94	18.00	45.06	1.39	N.S.	6.97	1.66	N.S.	6.49	1.63	N.S.
Residual	4			32.42			4.20			3.98		
Total	8											
Treatment Means and Standard Errors: Unthinned				35.0 ± 3.3			89.3 ± 1.2			85.3 ± 1.1		
6" thinned				40.8 ± 3.3			90.5 ± 1.2			86.7 ± 1.1		
12" thinned				42.4 ± 3.3			92.3 ± 1.2			88.2 ± 1.1		

WASTAGE IN FEEDING CHOU AND KALE

Wastage figures were obtained under English winter feeding conditions and were reported in a recent issue of 'Agriculture'. Losses were calculated on a dry matter basis.

There was an average wastage of 5.6 percent with cut and carted chou though this figure excluded subsequent wastage during feeding. This loss was small. The wastage was relatively low (14.2 percent) for grazed chou when the cows had access to only one or two rows. This entailed moving the fence twice daily on occasions. Grazing wastage rose to 28 percent where they gave the cows three or more rows with each move.

They measured higher wastage figures with heavy chou crops than with poor crops (a point stressed by a farmer at the Dannevirke forum). This accounted for lower wastage figures with broadcast crops (19.4 percent loss) when grazed 2 to 4 yeards at a time because broadcasting halved the yield. It is for this reason that there is less wastage with thousand-headed kale (11 percent) as compared with chou (17 percent).

In general, high grazing wastage was associated with an excessive frontage of break per animal.

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