ESTIMATING PASTURE PRODUCTION BY USE OF GRASS LENGTH AND SWARD DENSITY[1])

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SUMMARY

It was investigated to what extent in the determination of pasture yields clips can be replaced by estimates of the sward density and length of the herbage. In view of the results there is no preference for a logarithmic or a non logarithmic processing. Assuming that the variance about the regression line is independent on the estimation values, the results in 1959 at a yield level of about more than 4000 kg/ha were reasonable good.

The reliability was not so good on fields of which the sward contained more than 10 % of dicotyls.

By combining a small number of clips with a larger number of sward density and/or length estimates ("double sampling") it was found that a fairly considerable improvement could be effected in the reliability of the yield determination as compared to clipping only, without increasing the time needed for yield determination.

1 INTRODUCTION

The amount of herbage in a particular paddock is usually determined by clipping and weighing experimental plots. A sample is then taken of each clip in order to estimate the dry matter content, the gross yield of a paddock being the average dry matter yield of the plots converted to the total surface area.

There are several drawbacks to the practical application of this method. In order to discover the annual production of a paddock some 5 to 6 clips are needed per annum, and since in many cases the plots have to be protected against grazing cattle by fences or cages this method is fairly expensive. As a result the number of clips per trial harvest is limited; moreover it is required to keep the total area of the plots small compared to the total area of the paddock because clipped plots cannot be used for grazing and owing to variations in subsequent growth they are preferably avoided in each subsequent evaluation during the same season.

In Holland it is the usual practice to clip 5 plots of 4 sq.m. or 4 plots of about 5 sq.m. per hectare, but the less uniform the sward the greater the probability is that the average yield of a few plots only will vary fairly considerably from the actual yield.

The literature only contains a few references to the errors attaching to the clipping and weighing method. Research undertaken by FRANKENA (1934, 1935) and BOSCH (1956) shows that large plots exhibit a smaller variation than small plots, but that a sufficient number of small plots give a smaller standard error of the mean than a smaller number of large plots having the same total surface area. In fig. 1 GREEN (1949) shows the number of plots of a given size that should be cut on a field of varying grass length in order to

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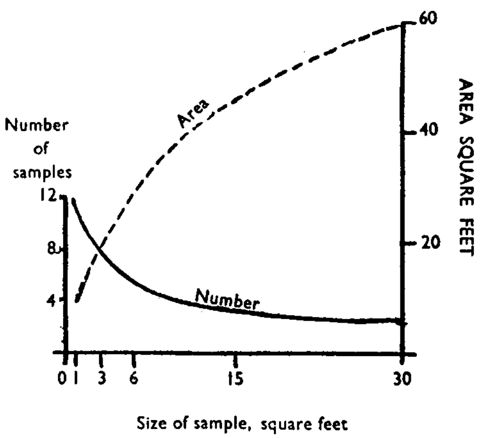

FIG. 1.

obtain a coefficient of variation of 10% for a yield of about 1570 kg per hectare. GREEN gives the size of the yield because it was found, that low yields were associated with a high coefficient of variation; this was also found by FRANKENA (1934).

By coefficient of variation is meant, therefore, the standard error of the mean expressed as a percentage of this mean. With 4 plots of about 5 sq.m. or 5 plots of 4 sq.m. we can expect a coefficient of variation of less than 10% according to this graph and under the conditions specified by GREEN. BOSCH (1956) found a mean coefficient of variation of about 4% on ungrazed land with an annual production of 9400 kg per hectare by use of four 5 sq.m. cages.

The disadvantages of the clipping method are offset by the advantage that it provides us with an objective index of the yield.

In several cases in order to arrive at a quicker and less expensive method the herbage output was estimated. Although FERRARI (1953) obtained good results in this way there is still the drawback that one is extremely dependent on the expertise of the valuers.

Other research workers have tried to discover correlations between the yield and density of the crop and/or grass length.

Both PECHANEC and PICKFORD (1937), PASTO, ALLISON and WASHKO (1957), EVANS and JONES (1957) and SPEDDING and LARGE (1957) conclude that sward density alone is not a good index of herbage production. This is manifest since the sward density is only a measure of the herbage in a horizontal direction.

SPEDDING and LARGE (1957), MAKKINK (1951, 1957) and VAN DER SCHAAF (1957) also conclude that grass length alone is not an adequate index of the yield; in this case all we have is an indication of the herbage in a vertical direction.

It is clear therefore that we must assume that the yield can be better assessed with a combination of sward density and grass length in some form than with either separately. As SPEDDING and LARGE put it: "In either case height and density must be regarded as complementary".

In 1957 articles were published in America (EVANS and JONES) and Holland (MAKKINK, VAN DER SCHAAF) on the relationship between dry matter yield and the product of sward density and length. In both countries it was considered that the correlation represented by means of a regression line through the origin was very promising.

2 OBJECT OF THE INVESTIGATION

The investigation discussed here was primarily intended as a means of discovering what degree of accuracy can be obtained by substituting sward density and grass length estimates for clips.

Secondly, we investigated how far it is possible to increase the accuracy by combining a small number of clips and estimates with a large number of estimates by the "double sampling" method as practised by WILM et al. (1944).

3 METHOD EMPLOYED AND TREATMENTS

In order to test under the conditions prevailing in Holland the results mentioned in the literature the following observations were made in 1957 and 1959 on a number of pastures every time a pasture was entered:

a 6 4 sq.m. plots per hectare were clipped, the herbage weighed and the dry matter content measured;

b within these plots 4 height measurements were invariably taken (these were summed in processing) and one estimate of sward density;

c the sward density and length were regularly determined over the field at a number of points (about 40 per hectare) in each pasture.

In this manner in 1957 6 fields of permanent grassland on river clay and 13 one- and two-year leys on sandy soil were sampled 79 times in all. In 1959 7 fields of permanent grassland on river clay, peaty and sandy soils and 2 one-year leys on sandy soil were included in the investigation; in all, the yield of 24 cuttings was determined in this year.

On the permanent grassland the sward in all fields was fairly mixed and of medium to good quality. *Lolium perenne* was one of the most important varieties; other important varieties included *Alopecuris pratensis, Holcus lanatus, Dactylis glomerata, Poa* varieties and *Phleum pratense.*

On part of the leys *Lolium perenne* was chiefly in evidence, while on others *Dactylis glomerata* was predominant.

The clover and herb contents were generally low with the exception of one field in 1957 and another in 1959 (> 10% dicotyls).

Moreover in 1958 and 1959 in two experimental fields of which the plots only varied as regards clover content the output of the plots was determined in the manner described under a and b.

The mean height of the crop was estimated by means of a measuring plank as described by MAKKINK (1951). This plank is marked with a scale division in centimetres; it is used by inserting it in the grass with one hand, placing the other hand about 20 cm in front of the plank so as to draw the grass down on to the plank. The mean grass length is then measured, viz. the line to which the plank is entirely covered with grass when that portion extending above the line is imagined as being folded over and helping to cover the plank up to the line.

In our investigation the sward density was determined by estimating the coverage of the ground as a percentage of the total area.

Cutting was done with a scythe as this gives a shorter stubble than the mower which was provided. The grass was weighed immediately after cutting and the dry matter content was determined in a drilling sample of each clip.

4 Methods of processing the results

The relationships between the weighings and estimates were examined statistically in various manners.

4.1 *Statistical processing by means of regression equations*

Linear regression $y = bx + a$ (1)

$\log y = b \log x + a$ (2)

Multiple regression $y = b_1x_1 + b_2x_2 + a$ (3)

$\log y = b_1 \log x_1 + b_2 \log x_2 + a$ (4)

y = dry matter content in kg/ha
x = product of sward density and length
x_1 = length in cm
x_2 = sward density in %
b, b_1 and b_2 = regression coefficients
r = correlation coefficient
s = estimation of the standard error.

In the case of linear regression (1) the formula for the variance about the calculated regression line is:

$$s^2 = \frac{\text{sum sq. } y - b^2 \ \text{sum sq. } x}{n - 2} \qquad (5) \quad \text{Snedecor (1959)}$$

The length of the expected confidence interval of y at the point x is represented by the formula:

$$2\,(t_{n-2})\, s \sqrt{\left(1 + \frac{1}{n} + \frac{(x - \bar{x})^2}{\text{sum sq.} x}\right)} \qquad (6) \quad \text{Snedecor (1959)}$$

In the case of linear regression according to (2), x and y in the above formulae are replaced by log x and log y.

In the text below zl is always taken as representing

$$\frac{\text{sward density in \% } \times \text{ length in cm}}{20}$$

4.2 *Statistical processing with double sampling* (Hansen et al., 1953)

Let us assume that it is required to know the mean yield $\bar{Y}$ of a pasture, that $\bar{x}$ is the mean of a large number of zl or 1 determinations (n) which has been correlated to $\bar{y}$ by a given method and that $\bar{y}'$ is the mean yield of a small number of clips (n'). $\bar{y}$ then has a smaller error than $\bar{y}'$ and can be approximated by means of the formula:

$$\bar{y}'' = \bar{y}' + b\,(\bar{x} - \bar{x}') \qquad (7)$$

b = regression coefficient between Y and X estimated by b', the regression coefficient between y' and x'.

For b it would be possible to fill in the value of the regression coefficient of a general regression line previously found; on the advice of the Centre for Mathematics in Agriculture in our calculations we invariably employ b′ which relates to each clip.

The improved variance may be represented by:

$$s_{\bar{y}''}^2 = \frac{S_Y^{\ 2}}{n'}\left[1 - r^2\ (1 - \frac{n'}{n})\right] \qquad (8)$$

$S_Y^{\ 2}$ = variance of individual observation estimated by means of the variance of y′.

A condition governing the use of these formulae is that r should be reasonably good. Compared to sampling without "double sampling", which still requires the same amount of time, the minimum correlation coefficient needed to obtain an improvement in the mean error $s_{y'}$ with an optimum n′/n ratio is denoted by the following formula:

$$r^2 = \frac{4\ C_1C_2}{(C_1 + C_2)^2} \qquad (9)$$

C_1 = cost of one estimate in mins.
C_2 = cost of one clip, weighing, dry matter determination + estimates in clip in mins.

The optimum number of estimates and the optimum n′/n ratio required to obtain the maximum possible accuracy per unit of time is shown in the following formulae:

$$n = \frac{C}{C_1 + C_2\ \sqrt{\frac{1 - r^2}{r^2}\ \frac{C_1}{C_2}}} \qquad (10)$$

C = total costs $C_1n + C^2n'$.

$$n'/n = \sqrt{\frac{1 - r^2}{r^2}\ \frac{C_1}{C_2}} \qquad (11)$$

5 Results when clipping and weighing are replaced by estimates of sward density and grass length

For 1957 the mean dry matter yield per cut, calculated from the yield of 6 plots per hectare and correlated to the mean of 40 zl determinations per hectare, gives the following regression equation (see (1), mentioned in 4.1):

$y = 28.4\ x + 503.3$ — n = 46, r = 0.80 ± 0.05, b = 28.4 ± 3.2, s = 333.1

For 1959 this equation is:

$y = 45.4\ x + 477.5$ — n = 21, r = 0.98 ± 0.009, b = 45.4 ± 2.09, s = 281.5

These regression lines are shown as a broken line in figures 2 and 3.

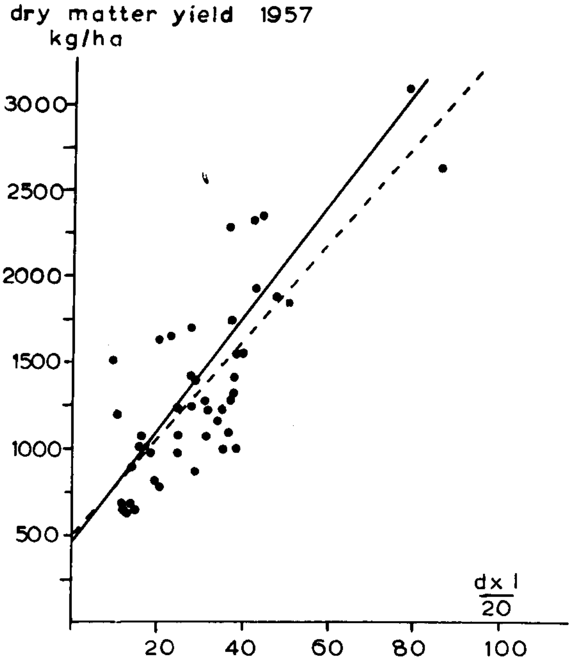

FIG. 2 THE RELATION BETWEEN DRY MATTER YIELD AND THE PRODUCT OF GRASS LENGTH AND SWARD DENSITY IN 1957.

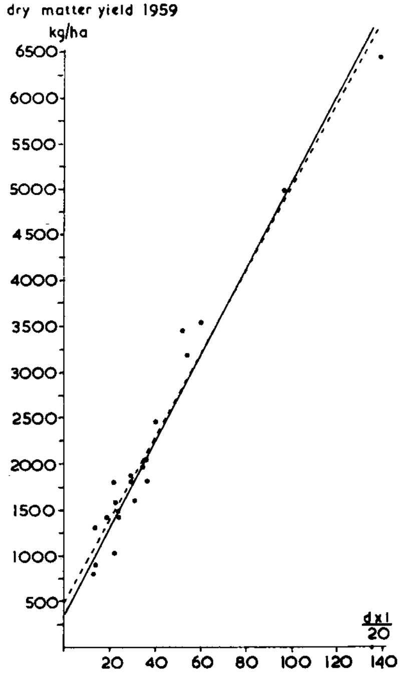

FIG. 3 THE RELATION BETWEEN DRY MATTER YIELD AND THE PRODUCT OF GRASS LENGTH AND SWARD DENSITY IN 1959.

Thus in both years there was a significantly positive correlation, but in 1959 it was substantially higher than in 1957.

However the regression coefficient varies significantly in the two years so that it is not permissibile to take the same regression equation for both years; this will be discussed further on page 220.

In addition the regressions are calculated from the individual observations of each plot clipped and shown as full lines in figures 2 and 3.

1957 $y = 32.6\ x + 470.3$

$n = 268$
$r = 0.85 \pm 0.02$
$b = 32.6 \pm 1.2$
$s = 480.1$

1959 $y = 46.8\ x + 373.7$

$n = 127$
$r = 0.97 \pm 0.005$
$b = 46.8 \pm 1.04$
$s = 370.2$

The latter regression line with its scatter diagram is shown in figure 4.

These calculations gave approximately the same coefficients as when the pasture averages were taken as the starting point. From this we can deduce that 40 zl determinations per hectare were as representative of the mean yield as 6 clips per hectare.

The data processed according to formula (2) gave the following result:

1959 $\log y = 0.8324 \log x + 2.0377$

$n = 21$
$r = 0.96 \pm 0.018$
$b = 0.8324 \pm 0.055$
$s = 0.0656$

In order to test the value of the estimates it is necessary to know what variance should be taken into account in estimating the output of a field.

In the following table 1 the expected length of confidence interval of the mean dry matter yield for a number of values of zl is represented by means of formulae (5) and (6) for the 1959 data. Table 1 also includes a column in which the expected confidence limits are shown, assuming there to be a logarithmic ratio between y and x (2).

By calculating the values in column IV, we assumed that the variance about the regression line is independent of the value of x; the figures in column IV may suggest that for a yield less than 3000 kg/ha the length of the confidence interval is very high, but it is less than 30% for a yield exceeding about 4000 kg/ha. We can remark but little about the expected error of a high yield, disposing of such a small number of observations in the region of high yields because of the very dry summer in 1959.

After all a linear regression seems to be reasonable when we look at figure 4. In this graph the yield of each plot clipped is correlated with its zl-value (for data of the regression line see on page 217). We are not sure of the reliability of the observation indicated by a cross in figure 4, the dry matter content being exceptionally high.

Table 1.

X	y = bx + a		log y = b log x + a	
	Yield kg dm/ha	The expected length of conf. interval of y as a percentage of the yield (P = 0.05)	Yield kg dm/ha	The expected length of conf. interval of y as a percentage of the yield (P = 0.05)
I	II	III	IV	V
12	1022	± 60.1	863	+ 40.8 — 29.0
20	1385	± 43.9	1320	+ 38.8 — 28.0
30	1839	± 32.8	1850	+ 38.2 — 27.6
$\bar{x}$	2230	± 27.0	1930	+ 38.1 — 27.6
70	3654	± 16.9	3746	+ 40.0 — 28.6
100	5015	± 13.2	5041	+ 41.9 — 29.5
140	6831	± 10.9	6670	+ 44.2 — 30.7

The expected length of confidence interval for low yields seems to be smaller with a logarithmic processing than with a linear processing assuming that in the former case instead of the latter the variance about the regres-

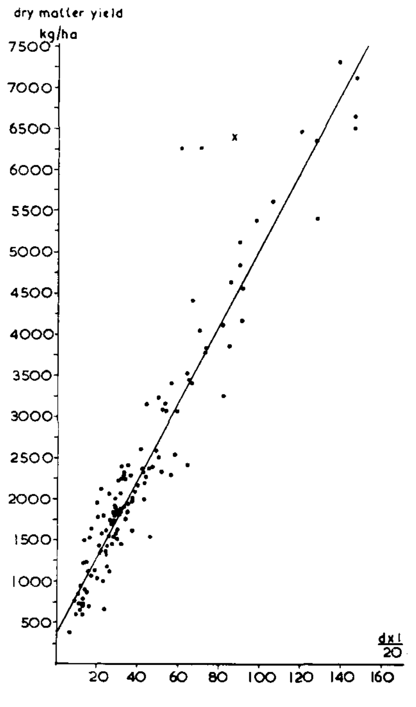

FIG. 4 THE RELATION BETWEEN THE DRY MATTER YIELD OF EACH PLOT CLIPPED AND ITS PRODUCT OF GRASS LENGTH AND SWARD DENSITY IN 1959.

sion line is independent of the value of x. However in both cases the variance seems to be somewhat dependent on the x-value.

The figures in table 1 do in fact show that the sward density and length estimates can only provide a rough estimate of the yield. Moreover it was found that a multiple regression calculation applied according to formulae (3) and (4) did not provide us with a considerably more reliable estimate of the yield.

In comparing the clip method with that in which the yield is deduced from the average of a number of estimates, the ultimate question is, how these methods compare as regards reliability.

In figure 5 the expected length of confidence interval of each cutting yield for 1959 is shown by a dot which is calculated by multiplying the standard error of the mean yield of 6 clips ($s_{\bar{y}}$) by twice the t value ($2.t._{n-1}\ s_{\bar{y}}$).

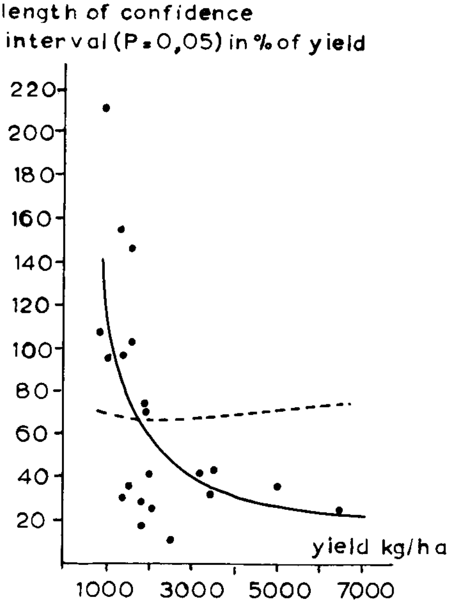

FIG. 5 THE EXPECTED LENGTH OF CONFIDENCE INTERVAL IN 1959 (P = 0.05).
• calculated from the weighing data only for each cutting;
——— ,, ,, linear regression y = bx + a;
- - - - - ,, ,, ,, ,, log y = b log x + a.

It is found that in 10 cases out of 12 the points denoting a length of confidence interval of less than 50% were derived from hayfields and in 7 cases out of 9 those denoting a length of 70% and over were derived from grazed land.

It can also be seen that in general, and especially with grazed land, there is a marked increase of the error with decreasing yields, so that a very wide margin of error should be observed in the case of yields less than about 1800 kg/ha.

For comparison the full and broken lines in figure 5 show the trend of the expected length of confidence interval calculated from equations (1) and (2) respectively by means of formulae (5) and (6) for varying yield levels.

Then in both cases it has been assumed that the variance about the regression line is independent on the x value, which only can be true by approximation.

So interpretetion is very difficult, but it seems worthwile to test these results next year to a large number of observations in a wider margin of yields.

In testing the use of regression lines the following questions arise:

1 Can a regression line, once it has been obtained, be used in subsequent years on all fields and by any person?

2 Does the error greatly increase when only the length of the herbage is measured and the sward density ignored?

In view of what already is stated on page 217 about the significant difference between the regression coefficients of the lines for 1957 and 1959 we might be inclined to answer the first part of question 1 in the negative. But we wonder whether any reasons can be adduced for this difference; the necessary reliance could not be placed on the 1957 observations so that in our discussions we mainly confine ourselves to the 1959 results.

It was found that the higher regression coefficient in 1959 compared to 1957 was accompanied by a higher dry matter content. The average dry matter content for 1957 was 19.6% (from 9.4 to 54.8) and for 1959 26.4% (from 17.7 to 48.0). It is possible to deduce from the 1959 data that the regression coefficient does actually rise with increasing dry matter content, as is shown in table 2.

Table 2.

1959	Regression line data $y = bx + a$; $x = zl$		
	n	r	b
15–20% dm	8	0.98 ± 0.015	47.2 ± 4.2
20–25% ,, ...	59	0.96 ± 0.010	41.4 ± 1.6
25–30% ,, ...	36	0.97 ± 0.010	48.3 ± 2.2
30–40% ,, ...	17	0.97 ± 0.014	67.8 ± 4.6
> 40% ,, ...	7	0.86 ± 0.106	83.0 ± 21.9

Further investigation is required to determine the annual effect on the relationship between dry matter yield and the product of sward density and grass length.

With regard to the effect of different fields it can be stated that no significant differences occur between fields with 90% or more grasses. But where the proportion of dicotyls exceeded about 10% it was found that the correlation coefficient for the dry matter yield per clip/zl ratio in the same clip gave a considerably poorer figure. This is obvious because dicotyls have a different weight distribution with respect to their length than monocotyls and will consequently have an unfavourable effect on both the sward density determination (Pechanec, 1937) and the length measurement. Pasto et al. (1957) found that where the sward contains clover (the percentage of clover is not stated) there is also a poorer correlation than in the absence of clover.

In 1957 the only pasture with a dicotyl percentage of > 10% gave a correlation coefficient of 0.68 (other fields between 0.80 and 0.96). In 1959 a field containing a high proportion of dicotyls gave r values of 0.54, 0.56 and

0.68, nor could these results be improved by other statistical processes.

Two experimental fields of which the plots only varied as regards clover content gave the following regression lines:

Table 3.

	n	r	b
1958			
< 10 % clover	24	0.73 ± 0.10	22.3 ± 4.5
> 10 % clover	29	0.63 0.11 ±	6.2 ± 1.5
1959			
< 10 % clover	26	0.95 ± 0.02	35.5 ± 2.5
> 10 % clover	28	0.73 ± 0.10	28.9 ± 5.4

The conclusion to be drawn is that lower correlations are found for fields with a high percentage of dicotyls.

In order to answer the question as to what extent the result of the yield determination according to the zl estimate is influenced by the person of the observer, in 1959 the observations were made by three persons independently of each other; although there was some slight variation between the observations of each person this was not reflected to any considerable extent after the results had been processed.

A second query is, what would the relationship be if the dry matter content were correlated to grass length (the length being estimated as is explained on page 213), leaving the sward density out of consideration. In 1957 this mean sward density per cut varied from 50.0 to 93.0% and in 1959 from 62.0 to 91.6%.

The regression lines according to (1) would then be as follows:

1957 $y = 96.2\ x + 441.2$

$n = 46$
$r = 0.70 \pm 0.08$
$b = 96.2 \pm 14.7$
$s = 396.0$

1959 $y = 205.8\ x + 184.2$

$n = 21$
$r = 0.98 \pm 0.009$
$b = 205.8 \pm 9.1$
$s = 272.1$

$\log y = 0.9162 \log x + 2.4359$

$n = 21$
$r = 0.97 \pm 0.013$
$b = 0.9162 \pm 0.055$
$s = 0.0599$

The following table 4 shows the expected length of confidence interval of the dry matter yield from reading the mean grass length.

It is found that the results with the use of grass length only are as good as with the use of zl, even somewhat better, although not significanttly so. Should this conclusion also be valid for subsequent years the use of grass length would be greatly preferable as it means a saving of 40 sward density

Table 4.

X	y = bx + a		log y = b log x + a	
	yield kg dm/ha	the expected length of conf. interval of y as a percentage of the yield (P = 0.05)	yield kg dm/ha	the expected length of conf. interval of y as a percentage of the yield (P = 0.05)
4	1007	± 57.9	972	+ 36.0 — 26.5
6	1419	± 40.9	1409	+ 34.7 — 25.8
$\bar{x}$	2230	± 26.0	1930	+ 34.3 — 25.6
15	3272	± 17.7	3262	+ 35.4 — 26.1
20	4301	± 13.6	4245	+ 36.6 — 26.8
25	5330	± 11.0	5208	+ 37.8 — 27.4

determinations per hectare (about 20 minutes). Moreover the determination of sward density is a subjective and exacting task and practically impossible with a long crop.

6 Double sampling

In the above a general relationship was sought between the weighed yield and the estimates of sward density and grass length. In the double sampling discussed here this relationship is again determined for each yield determination. A large number of estimates are then employed in order to reduce the variance resulting from the non-representative character of the small number of clips. For the methods of processing reference may be made to 4.2.

With the help of formula 9 it is possible to calculate what correlation coefficients are required to make it likely that such double sampling will reduce the variance, an equal amount of time being spent per yield determination. In the case of zl or 1 determinations these minimum values of r are found to be 0.38 or 0.28 respectively, it being assumed that C_1 equals one minute and half a minute respectively and that C_2 equals 25½ and 25 minutes respectively.

In linear regression with zl the correlation coefficients of the clips chiefly varied from 0.60 to 0.98 with two exceptions of 0.28 and 0.49. In the case of linear regression with grass length the r values varied from 0.62 to 0.97 with two exceptions of 0.47 and 0.49, and with multiple regression from 0.73 to 0.99 with one exception of 0.48. Hence it was only in one case (r = 0.28) that the minimum value was not reached.

In figure 6 the standard error of the mean yield obtained in double sampling ($s_{\bar{y}''}$) is plotted on the y axis against the standard error of the mean yield with clipping only ($s_{\bar{y}'}$). The value taken as correlation coefficient r in the formula for $s_{\bar{y}''}$ (8) is that obtained with the use of multiple regression, since it was usually a fraction better than the r value obtained in linear

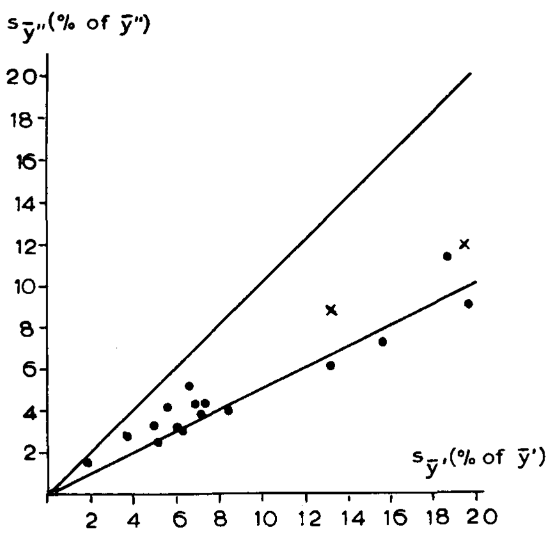

FIG. 6 COMPARISM BETWEEN THE STANDARD ERROR OF THE MEAN YIELD WITH DOUBLE SAMPLING (y-axis) AND THE STANDARD ERROR OF THE MEAN YIELD WITHOUT DOUBLE SAMPLING (x-axis) BOTH EXPRESSED AS A PERCENTAGE OF THE MEAN YIELD.

with zl or 1. Three observations have been omitted, its number of clippings being to small to apply multiple regression.

Referring to the figure, the 45° line denotes the limit beyond which there is no further improvement of error. At the same time the line is drawn where a 50% improvement of error occurs. It is then found that for a correlation coefficient of 0.90 or more the improvement of the standard error of the mean is 50% or more, whereas with an r value of 0.70 or less this improvement is 25% or less. The two crosses denote clips of grazed land in which the n'/n ratio was 8/40 per 0.33 ha instead of 6/40 per ha; despite 8 clips on such a small field the error could be considerably improved by making 40 additional zl determinations.

It may be asked what n'/n ratio is finally to be preferred in order to obtain the greatest possible improvement in the standard error. This involves the time factor. Clipping, weighing and dry matter deermination occupy a great deal of time, a few additional length estimations per field make little difference.

In the following table the n'/n ratio required in order to obtain the maximum reliability per unit of time is calculated for the correlation coefficients 0.70, 0.80 and 0.90 by means of the formulae (10) and (11) starting from 5 clips viz. the specified minimum per ha when the size of the clip is 4 sq.m. If one is not too pressed for time, according to table 5 it is advisable to spend an additional quarter of an hour on 39 (74—35) length determinations in order to achieve the maximum efficiency of time. Table 6 illustrates the extent of improvement of the mean error with different n'/n ratios for two cuttings made in 1959, viz. with r values of 0.94 and 0.76 respectively.

This table shows that it is better to spend, say, 25 minutes extra on 50 length determinations than on an additional clip (compare 5 : 50 with 6 : 0).

It is possible to assign a particular value to n'/n, according to choice depending on the time available and the reliability it is required to give to the yield to be measured.

Table 5.

r	opt. n'/n with zl	opt. n'/n with l
0.70	5/25	5/35
0.80	5/34	5/47
0.90	5/52	5/74

Table 6.

n'/n	$s_{\bar{y}}''$ as a percentage of $\bar{y}''$ (first line of $\bar{y}'$) ; correlation to length					
	n = 5	n = 6	n = 8	n = 5	n = 6	n = 8
r = 0.94				*r = 0.76*		
1 : 0	22.6	18.4	13.4	18.7	15.3	11.2
1 : 2.5	13.7	11.0	8.4	14.6	12.0	8.8
1 : 5	11.0	9.0	6.7	13.3	10.9	7.9
1 : 10	9.2	7.5	5.6	12.6	10.3	7.5
1 : 15	8.6	6.9	5.1	12.3	10.1	7.4

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