THE DETERMINATION OF PASTURE YIELD [1]

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SUMMARY

The determination of the gross and net yield of pasture is discussed. As regards the gross annual yield, it is possible to distinguish between the method which is independent of the farmer's use, and that which depends on the use. The use of cages as compared with fenced-off trial fields: some pros and cons. Reference is also made to results of experiments relating to the extent of the standard deviation in similar plots used for measuring yield.

In determining the net yield of pasture it is found that the method of conserving winter forage and the grazing method employed have a great effect on the ultimate annual yield. Reference is made to some norms which may still be used to compare the yield of fields where the use differs.

1. INTRODUCTION

Up to a few years ago it was almost customary in Holland to harvest the first cut in the spring when investigating the effect of a given practice on pasture output. Moreover, this harvesting was usually carried out in the hay stage, viz. when the material was relatively old. After the use of nitrogen had become more general, the first crop was mown earlier, as in the case of harvesting for winter feed. In certain cases harvesting of the first cut can supply sufficient information on the effect of a specific practice such as potash fertilization.

But this is insufficient for other factors that may affect the yield, e.g. spraying, infiltration, organic manuring and liming. This is also true of practices for promoting the growth of clover in pasture, and in comparing strains and mixtures. In these cases it will be necessary to adopt the practice of harvesting more cuts or determining the total annual output.

Gross and net yield

In the foregoing, by yield was meant the amount of grass determined by direct measurement (mowing and weighing), i.e. the *gross yield.* A distinction is made between this gross yield, or yield on the stalk, and the *net yield* determined by indirect measurement. This is calculated with the aid of norms from the number of grazing days, the milk yield and growth of the livestock, plus the amount of winter feed.

2. DETERMINATION OF THE GROSS YIELD

As already observed, up to a few years ago in pasture practically only the yield of the first cut was determined, and in a few cases that of the second cut. When this was done in fields mown for hay it was unnecessary to fence off the plots to be harvested. But now that it is required to determine the yield of a greater number of cuts it is necessary to protect the plots from being bitten down by grazing livestock.

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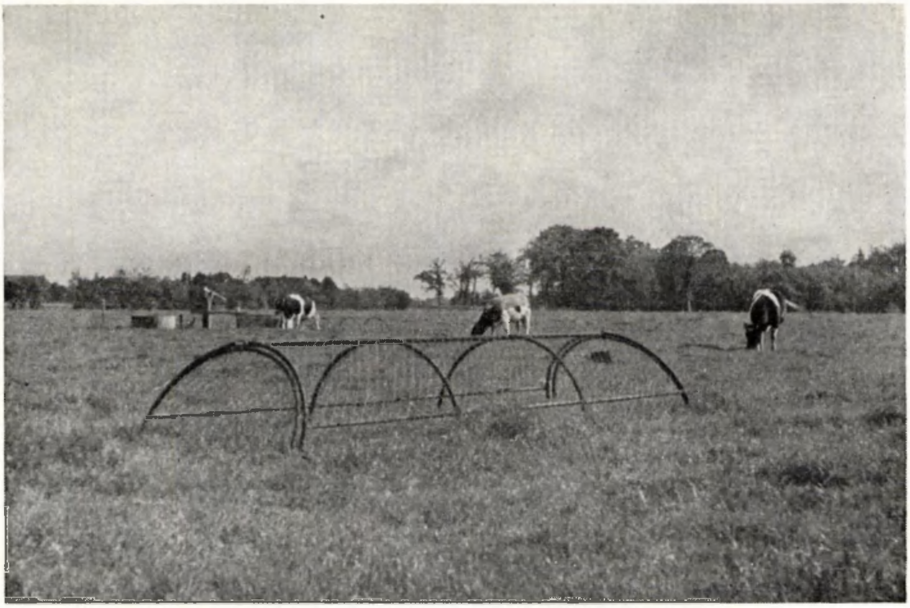

FIG. 1 CAGE USED FOR DETERMINING YIELD.

Up to 1949 barbed-wire fences were generally used in Holland for this purpose. In 1949 cages were used for the first time by the Central Institute for Agricultural Research at the Experimental Farm at Selmien (Friesland) and on a trial field at Ede. These cages, consisting of a frame covered with chain link wire netting, protect an area of 5.04 sq. metres (4.20 $\times$ 1.20 metres) from being grazed down (see Fig. 1). The grass growing underneath these cages can be harvested at any time required. The corners of the cages are fixed with staples so as to prevent livestock from shifting them.

2.1. CAGES OR FENCED-OFF SECTIONS

In certain experiments in which the comparatively small area of the plots to be harvested is no disadvantage, the use of these cages has the following advantages as compared with fenced-off plots :

a labour-saving in laying out and harvesting the trial fields ;
b less trouble from grazing down by livestock breaking through ;
c a reduction in the amount of grass harvested which is frequently lost ;
d trial field owners prefer cages to barbed-wire fences ;
e the cages are easily moved, and if desired the yield of another site can be determined after each cutting.

On the other hand there are also a number of disadvantages, viz. :

a when fertilizing with nitrogen, for example, the trial field owner may easily drop some of it under the cages ;
b much more care is required in mowing down the comparatively small area ;
c a smaller part of the object is harvested ;
d cages are more expensive than fencing.

It will depend on the type of trial field and the desired precision whether cages or fenced-off sections are preferred.

2.2. Methods of determining yield

In general it is possible to distinguish two methods of determining the gross yield of pasture (annual output), i.e. independent or dependent of the use of the land by the trial field owner.

a Independent of use

This is the method in which a part of the land is mown at given periods in order to determine the yield (e.g. every 5 weeks, as in the case of the CI-203 trial fields [2]). This can be done by means of fenced-off trial sections which are usually in the same place during the whole season, or by means of cages which, if desired, may be moved after one two cuttings.

b Dependent on use

In this method sections or strips (e.g. 5 sections of 4 sq. metres per hectare) are harvested shortly before the livestock are pastured, or at the same time as mowing for the winter feed, in order to determine the amount of grass then available. The growing periods usually vary for each crop harvested, and depend on the way in which the farmer uses the land. One drawback of this method is that the growth during the grazing period is not reflected in the total annual yield. In the case of land grazed, for example, 4 times in 5 days during a season, this represents 20 days, or 10% of a total growing period of 200 days. It is therefore better to use cages, the area protected being harvested directly the livestock are moved to another pasture. After a crop has been harvested the cages are moved to a part grazed down (if necessary after mowing down grass left and applying nitrogenous fertilizer), and the crop again harvested at the end of the next grazing period. In this way a better idea is obtained of the total annual yield.

As was remarked above, when sections or strips are mown clean before the livestock are pastured the growth during the grazing period is unaccounted for in the total annual yield. In grazing tests the error made in calculating the gross yield from a comparison of the gross and net yields in a single grazing period will be smaller as the pastures are grazed by a greater number of livestock and the grazing period is thereby reduced. With a smaller livestock population grazing will often take a week or more per plot, and the grass yield determined may then be far too low.

Another objection to mowing down sections is that the stubble left behind by livestock usually varies in length from what is left after mowing. Hence in grazing tests in which it is required to determine the amount of grass actually consumed by livestock, it is not only desirable to measure the sections before pasturing livestock, and the cages on mowing livestock to another

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[2]) In the CI-203 trial fields which in Holland have been laid out since 1943 in different types of pasture land, the yield of a small area is determined (e.g. 10 sq. metres) with standardised fertilization (70 kgs N, 120 kgs K_2O, 80 kgs P_2O_5 per hectare) according to a fixed scheme of mowing (every 5 weeks). The object of this investigation is to determine the effect on the gross yield of such different factors as type of soil, state of fertilization, botanical composition and water level.

pasture, but also to calculate the amount of grass left behind by mowing sections on the part grazed down.

2.3. Comparison of gross yield measurements

During the period 1949–1951 three methods of determining the gross annual yield were compared at a trial field at Ede. The results were as follows:

	Yield in kg of dry matter per are	
Sections (before pasturing)	80.7	(89)
Cages (after changing pasture)	91.9	(101)
Cages (mown every 5 weeks)	90.6	(100)

Compared to the standard method (5 weeks), after the change of pasture the cages yielded practically equal amounts, whereas before pasturing the sections yielded about 10% less.

2.4. Which method of measuring output is desirable?

In deciding which method to use one should first of all consider the purpose for which the yield is being determined. The following 3 cases may be distinguished:

a *Comparison of the annual yield of pasture in different fields or establishments in connection with soil type, state of fertilization, water level, botanical composition, etc.*

In this case the gross yield is determined by a standardised method, for instance by harvesting every 5 weeks with the same degree of fertilization. The trial sites or cages are arranged on an apparently even spot which is fairly representative of the entire field. Soil and botanical samples are taken at this spot and the water level checked. The yield level of the various trial sites can be studied in connection with above-mentioned factors.

b *Comparison of the gross and net annual yield of a field*

By means of a number of cages placed in scattered positions in the field, and harvesting the area so protected at the end of the grazing period or at the same time as any mowing for winter feed, a good impression is obtained of the gross annual yield of the field as used by the farmer. The number of cages should be at least 4 to a field in the case of fields of up to about 1 hectare. By using a greater number of cages the actual gross yield will be better estimated.

Since the use of different fields generally varies, this method does not permit a direct comparison of their gross yields. For this purpose it is better to harvest the scattered cages by a standardised method.

c *Determination of the gross yield and the quantity consumed by livestock in grazing tests*

In this case the amount of grass available to livestock and consumed by them should be measured as accurately as possible. Hence the following method is desirable:

1 mowing down sections before pasturing;
2 mowing down cages after change of pasture;
3 measuring or estimating what is left after change of pasture.

In order to calculate from these three data the amounts available and consumed use can be made of the following formula devised by LINEHAN and others:

$$\text{amount consumed} = (c - f)\,\frac{(\log d - \log f)}{(\log c - \log t)}$$

in which c = store at commencement of grazing period (sections)
d = store at end of grazing period (cages)
f = remainder at end of grazing period.

Instead of using this rather complicated formula, the amount consumed may also be calculated from the initial store plus half the additional growth of the grass during grazing, less the rest of the amount. Thus consumed by the end of the grazing period $= c + \frac{d - c}{2} - f$.

LINEHAN's formula and the simple one drawn up by ourselves were used in a series of observations made by LINEHAN in 1947. The result of this com-

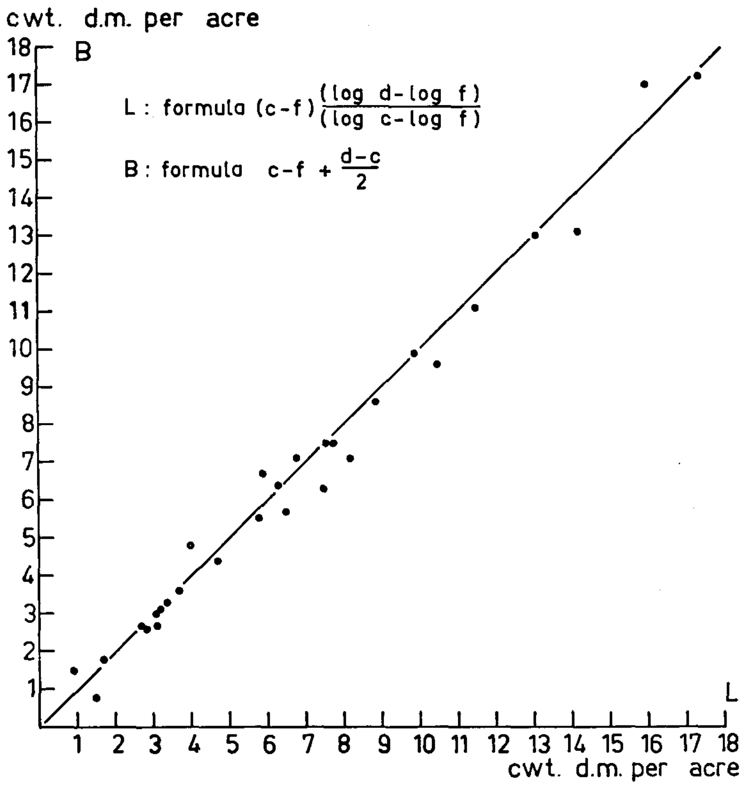

FIG. 2 THE AMOUNTS OF GRASS CONSUMED, CALCULATED BY TWO DIFFERENT METHODS.

parison is shown in Fig. 2. It is found that both formulae give practically the same result, so that the use of the simple formula is sufficient.

2.5. The magnitude of error in measuring yield

In 1934 experiments were carried out by Frankena in order to investigate the effect of the shape, arrangement and size of the harvested sections on the standard deviation per section (S %). The smallest sections were ¼ of an are, and plots of 4 or 5 sq. metres were not compared.

In 1953 a test was carried out at the Experimental Farm at Selmien in which the yields were compared of sections 1.20 metres in width and varying in length (2, 4, 8 and 36.7 metres). The yields with the calculated standard deviations were as follows:

Length of plots (in metres)	2	4	8	36.7
No. of repeats	32	32	32	4
Kg dry matter per are	33.2	31.8	33.1	33.9
S	5	3.8	2.9	1.9
S %	15	11.9	8.9	5.7

As in Frankena's experiments, a clear increase in S % was also found in the case of the smaller plots. In the case of plots measuring 4 × 1.20 sq. metres the standard deviation per plot is 11.9 %, or in other words, with 4 repeats the mean error of the average is about 6 %.

On working out the results over several years of CI-203 and other trial fields, using both sections 25, 30 and 50 sq. metres in area and cages scattered or not scattered over the field, the following was found:

	No. of tests	Kg dry matter per are	S	S %
25, 30 and 50 sq. metre sections ..	25	92	4.4	4.8
Cages (not scattered)	6	89	5.4	6.1
Cages (scattered)	12	94	7.5	8.0

Owing to the greater number of uneven places in the field the cages scattered over the entire field give a somewhat larger S % than the cages lying fairly close together. It is found, however, that by using at least 4 cages for determining a yield, the average yield of a field can be determined with reasonable accuracy.

3 Determination of the net yield

The net yield of pasture lands is determined indirectly via the livestock. With the aid of Geith's norms the annual yield of starch equivalent is calculated from the number of grazing days, the milk yield and the growth of the livestock during grazing, plus the amount of winter feed supplied by the field. In these norms a distinction is made between feed required for maintenance and feed required for production (milk and growth). They have been extended somewhat as regards production, and are shown in the following table.

FEED FOR MAINTENANCE

Per 100 kg live weight per 24 hours	kg starch equivalent
Calves and young cattle up to 200 kg	0.70
Young cattle of 200–400 kg	0.65
Cows of 400–600 kg	0.55
Cows over 600 kg	0.45
Dry cows	0.55
Foals	1.–
Horses on light work	0.80
Horses on medium-heavy work	1.–
Sheep (per animal per day)	0.70

FEED FOR PRODUCTION

Milk per kg up to	2.99 % fat content	0.24
	3.00–3.19	0.25
	3.20–3.39	0.26
	3.40–3.59	0.27
	3.60–3.79	0.28
	3.80–3.99	0.29
	4.00–4.19	0.30
	4.20 and over	0.31
Growth per kg increase in weight	up to 500 kg	2.5
	500–600 kg	3.5
	over 600 kg	4.5

When using these norms the following points should be remembered.

For the *milk production* in a given field it is desirable not to include the amount of the first 2 milkings for this field, but the amount of the first 2 milkings after changing pasture. This is necessary in order to minimise the effect on production of the previous field.

The weights should be known as accurately as possible so as to be able to calculate the starch equivalent required for maintenance and growth. In a number of Central Institute tests it was found that over four successive years the change in weight varied from -0.25 to $+0.58$ kg per animal per day. An inaccurate estimate of the weights may lead to comparatively large errors. As far as possible it is advisable to weigh the cows at the same time of day, e.g. immediately after milking.

But in order to calculate the net yield of a field it is not only necessary to take into account the cattle yield, but also that of winter feed provided by the field in question. This means the batches of hay, silage, dried grass and grass for stall feeding. It should also be pointed out that the method of conservation adopted greatly influences the amount of starch equivalent provided by a field. For instance, more than 40 % of the starch equivalent may be lost in haymaking, whereas in drying the loss is only 10 %. In grazing also great differences in losses are obtained which may likewise vary from 10 to over 40 %. The extent of such losses has a marked effect on the total net annual yield, as the following example shows:

Haymaking and drying compared with grazing	Kg starch equivalent per hectare	
	gross	net
a Grazing yield (30 % loss)	5000	3500
Hay 1st cut (40 % loss)	2500	1500
Total yield	7500	5000
b Grazing yield (30 % loss)	5000	3500
Drying 1st and 2nd cuts (10 % loss)	2500	2250
	7500	5750

Thus with the same gross yield, the same field gives a 15 % higher net yield by drying instead of haymaking.

When using different grazing methods it is also possible to obtain a very different net yield as a result of the varying losses. In a grazing experiment in which pasturing with varying grass-lengths was compared, the following result was obtained:

	Pasturing at kg per are		Yield in kg starch equivalent per hectare		Loss
	dry matter	starch equivalent	gross	net	
6 grazings	18	10.8	6400 (100)	4600	28 %
5 grazings	23	13.7	6800 (106)	4400	35 %
4 grazings	30	18.0	7200 (112)	3600	50 %

When pasturing on longer grass, i.e. grass not grazed so frequently per season, it was found that the gross annual yield increased 6 and 12 % respectively, but that the net annual production fell to a much greater extent, so that after 4 grazings the losses were 50 %, as compared to 28 % for 6 grazings.

When the gross and net yields of a number of fields were compared at the Experimental Farm at Selmien, the following was found:

No. of fields	No. of operations				Mean
	haymaking	ensiling	drying	grazing	% loss
2	2	1	—	2	51
1	2	—	—	3	39
4	1	—	—	4	35
1	1	—	1	3	28
1	—	1	—	4	26
3	1	—	2	4	16 [1])

[1]) Used 7 times.

The above shows quite clearly that by calculating the net annual yields of pasture lands one can first of all form an estimate of the amount obtained by the farmer by the method employed, but not a direct estimate of the productivity of the fields. Moreover, a direct comparison of the productivity by means of the net yields is impossible if there are differences in use, and, what is more, differences in nitrogenous fertilization. To make such a comparison it is desirable to convert the net yields into gross yields in the first instance, and then to reduce the nitrogenous fertilization to the same level.

For the *net – gross* (starch equivalent) calculation the following values may be employed:

	Gross yield	100
	Net yield for:	
a	stall feeding	95
b	ration grazing	85
c	rotational grazing (15–20 head of large cattle per hectare)	75
	in long grass	60
	in short grass	80
d	stationary grazing	60
e	haymaking in good weather (cocks)	60
	in bad weather (cocks)	45
	drying on hurdles	60
f	silage good pH < 4.3	80
	medium pH 4.3–4.5	75
	poor pH > 4.5	70
	poor without silo pH > 4.5	60
	predried silage	80
g	artificial drying	90

For comparing the yields of fields with different nitrogenous fertilization the following norms may be used in order to reduce the yields to the *same N level:*

	gross	net
per kg N per hectare	20 kg dry matter	–
	10 kg starch equivalent	7 kg starch equivalent

In certain cases these norms may actually differ from fields in which nitrogenous fertilization has a greater or less effect, but where the differences in nitrogenous fertilization are not excessive, these differences are unimportant. Assuming that the net effect per kg of nitrogen per hectare varies from 5 to 9 (average 7), where the difference in N level between fields compared amounts to 50 kg N per hectare, 50 × 7 kg of starch equivalent will be calculated, while this may amount to 50 × 5 or 50 × 9 kg or starch equivalent. For a total annual yield of 3500 kg of starch equivalent per hectare this may represent an error of 100 kg of starch equivalent, or about 3 %.

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