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Yield pattern of grassland in terms of farm management

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Summary

The yield pattern of grassland is determined by technical and economical factors. Some of the technical aspects (soil type, climate, growing conditions) cannot be influenced or hardly so, while others can be (grazing and mowing regime and fertilization). Some economical aspects which are important when management is taken into account are: labour, soil, capital and price ration of the production factors.

Much technical advice and many instructions result in a yield pattern with a distinct top in spring (especially in May). The maximum grassland yield also shows a yield pattern with a top production in May and June. A preliminary calculation showed that in terms of farm management a maximum grassland yield, as the main object of pasture farms, did not seem to serve a useful purpose under the prevailing conditions.

Based on a mathematical model the optimum management was analysed for the various farm situations.

Fig. 2, 3 and 4 show some data of the yield patterns belonging to these farm managements.

The average yield obtained in May and June is 44% (40–50%) of the total yield, that in July and August 35% (30–40%) and in September and October 21% (17–26%). The yields of May and June and those of July and August were negatively correlated. There was no or hardly any correlation between the yields of June and July, those of August and September and those of September and October. Most likely, the acreage cut will figure greatly in this.

Introduction

Management of grassland farms is very complicated. Whereas on an arable farm the crops grown, at the same time, are the final products, on a grassland farm it is an intermediate product which can only be turned to account after it has been converted to milk and meat by the animal. Another difference is that grassland is harvested more times per season. The various harvesting dates are not fixed and are dependent on grassland use. In grazing the herbage is harvested at an earlier stage than in cutting for winter rations.

When yield pattern means the distribution of the total grassland yield in the months of the growing season, it will be clear that we cannot merely mention one yield pattern of grassland. Many yield patterns are possible and many factors will affect it.

This article is meant to give some idea about the way in which these problems are studied at the moment.

Factors affecting the yield pattern

The yield pattern of grassland is dependent on many factors. Some of these cannot be influenced by man or hardly so, while others can.

Not aiming at completeness, we mentioned of the first group: soil type, climate (temperature, light intensity and rainfall) and the condition of the fields (moisture status). Factors determined by men are: mowing and pasturing regime and fertilizer application of grassland. In fertilizing mainly nitrogen application is considered, assuming that the potassium and phosphorus status of the soil correspond with the results of soil analysis. This does not mean that potassium and phosphorus should not affect the yield pattern.

In terms of farm management the yield pattern will also be influenced by a number of completely different aspects. Again not aiming at completeness, we mention, for example: labour supply, labour requirement, acreage available, nature of the farm (mixed or grassland farm), allotment, situation of the farm buildings, cost of soil, labour and buildings, and the price proportion of the various production factors. All these aspects, to be divided into technical and economical factors, determine optimum farm management and the belonging yield pattern of the grassland.

Regarding the technical aspects, it is pointed out that the yield pattern is greatly influenced by a number of requirements to be met. In the first place the pasture grass has to meet certain standards and so does the cutting stage of hay and silage.

The following advice from a number of advisory papers clearly demonstrates these standards:

'Suitable pasture grass is young grass with an average length of some 10 to 12 cm, which has grown within 30 days.'

'To silage wilted material, young and leafy herbage is required (15–18 cm long). This means cutting at a young stage, the herbage may not be "shooting" yet.'

'A suitable stage to cut for silaging flail-harvested material is, when most grasses are at the heading stage.'

'The correct cutting stage of hay is difficult to indicate precisely. Cutting should take place within the period from the beginning of heading to the beginning of flowering.'

Advice on nitrogen dressing and the advisable yield percentage of the first cut also determine the yield pattern. The advice on nitrogen fertilizer is: a high application in spring, not being to careful in May and June and then gradually decreasing the applications. This advice is based on the nitrogen effect being considerable in spring and decreasing gradually afterwards.

The result of this nitrogen fertilizer distribution is generally that 40 to 50% of the grassland acreage is to be reserved for grazing in spring. The remaining part, another 50 to 60%, can be mown for the first cut. If suitable pasture grass is to be continually available and good quality roughage is to be harvested, the first cut will generally have to be harvested before the first of June. All these instructions and requirements together add up to a yield pattern, of which a high percentage of the total yield is harvested, especially in May and to a less extent in June.

Maximum grassland yield and yield pattern

Alberda's investigations (1968) have shown that grassland yields may be over 20 ton dry matter per ha. Conditions for such high yield are:

Table 1. Yield pattern (distribution of the total yield (%) in the months of May through October) belonging to the maximum grassland yield.

Month	Harvest at maximum dry matter yield per cut	Harvest at average dry matter yield of 4 ton/cut/ha
May	43	25
June	0	23
July	30	23
August	16	16
September	0	0
October	11	13

- optimum water supply (sprinkler installation)
- optimum mineral supply, requiring regular crop analyses
- rapid removal of the herbage cut, achieved by artificial drying.

In these experiments the grass was cut:

a. when growth of a closed sward stops, i.e. when a maximum yield was attained;
b. when the average yield was about 4 ton dry matter per ha.

A yield of 20 ton dry matter was achieved by both harvesting methods. The yield pattern belonging to these harvesting methods is shown in Table 1.

An obvious point is, whether in terms of farm management – under the prevailing conditions – maximum grassland yields should be the main object. To investigate this, a preliminary calculation was set up with Alberda's data (1968), without considering animal nutrition aspects. Proceeding from a central grass drying plant with a daily capacity of 24 ton dry matter (about 160–200 ton fresh grass), workin at 100% capacity; with an average yield of 3 ton dry matter per cut per ha, this means that per day 8 ha grassland should be cut for the drying plant throughout the season (25 April to 1 November). Fig. 1 shows a scheme of grassland use in this case.

A total acreage of 384 ha grassland will satisfy the drying plant requirements. In May and June 224 ha will suffice. After June a larger area is necessary, because of

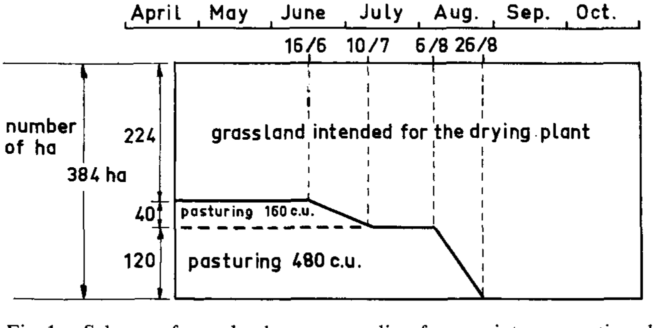

Fig. 1. Scheme of grassland use proceeding from points as mentioned in the text. One cattle unit (c.u.) is a quantity into which all ruminants and horses can be converted. In this calculation: 1 milking cow = 1.0 c.u.; 1 heifer = 0.5 c.u.; 1 calf = 0.3 c.u.

Table 2. Yield pattern (pro rata yield distribution) belonging to the scheme in Fig. 1.

Months	Yield distribution (%)	
	all 384 ha	only 224 ha grassland cut throughout the year
April + May	23	25
June	18	20
July	17	19
August	16	16
September	13	10
October	13	10
	100 = 14.5 ton DM/ha	100 = 18 ton DM/ha

the decreasing growth rate of the herbage in the course of the growing season.

Grassland not yet intended for the drying plant is grazed by cattle (40 ha until 10 July, 120 ha until 26 August). The yield pattern is given in Table 2.

Both yield patterns show a top in May and June, a logical result of a maximum grassland yield being the main object. The total dry matter yield of 14.5 ton per ha is rather lower than the 20 ton dry matter mentioned before. This is because farm management was also taken into consideration, here. The drying plant requirements only already affect the yield pattern considerably. The 224 ha grassland cut throughout the year neither yield 20 ton dry matter per ha which is also due to the average yield being 3 ton dry matter per cut per ha. The average yield with maximum production is 4 ton dry matter per cut. A great advantage of the younger harvesting stage is the higher nutritive value of the produce. As the herbage is harvested at an older stage the nutritive value will decrease. The difference in starch equivalent yield, a standard for the nutritive value, in harvesting at 3 or 4 ton dry matter will therefore be very small.

The calculation further shows that these 384 ha grassland can be grazed by 940 milking cows with belonging young stock (= 1225 cattle units) and that the labour requirement is 34 men. This number is based on a labour supply of 200 man-hours per month, and a labour requirement of 4.6 man-hours per cattle unit (c.u.) in the busiest period, 1 man-hour per ha grassland for fertilizer application and management and, on an average, 2 man-hours per ha grassland for sprinkling. Accordingly, each man can handle 11 ha grassland (384/34) grazed by 28 milking cows with belonging young stock.

The gross profit per man-power is Dfl. 19,500. This gross profit was calculated by subtracting from the milk and meat returns of 28 milking cows: milk replacer for the calves, cost of veterinary aid, interest and various other costs, drying cost of the plant (Dfl. 0.10 per kg dry matter), rent, fertilizers (600 kg nitrogen, 365 kg potassium and 125 kg phosphorus) and the building investments (Dfl. 200 per dairy cow).

The cost of crop analyses and of the sprinkler installation were not deducted, but on the other hand, the savings on farm machinery (no cutter bar, no tedder, no self-loading trailer) were neither counted in.

In comparing this gross profit with that of farms, where maximum yields are not the aim, only a small difference is found.

Naturally, the final result of this calculation is determined by the principles on which it is based, but we do not think that changing the basic points would affect the results in such a way as to considerably increase the differences in the gross profits. For instance, if the drying plant requirements should be considerably lightened, this would probably be associated to increased drying costs. Cutting for hay or silage instead of grazing would probably be associated with increased labour requirement or additional contractor costs. It is an open question whether these increased costs would be offset by increased income.

Under the prevailing conditions it seems therefore that maximum yields, as the main purpose of grassland farms, would serve no useful purpose. The profits are not or hardly offset by the cost of the conditions required (a drying plant, optimum fertilizer application, sprinkler installation and crop analyses).

Investigation of the optimum yield pattern

The ideal yield pattern will be one in which equal amounts of grass can be utilized per time unit. Levelling the yield pattern is theoretically possible by not applying too much nitrogen in spring, and as much as technically feasible in late summer.

Whether such a pattern is advisable in terms of management is one of the points under investigation, the lay-out of which will be discussed with some of the preliminary results.

An attempt was made to combine the alternatives from which the farmer continually has to choose in a mathematical model (Bosch and van Boven, 1967). Hence, the grazing season was divided into a number of five-day periods (from 1 May through 20 June), after this date into 10-day periods (from 21 June through 30 August), whereas the months of September and October were considered as one period. Based on experimental data an attempt was made to determine the growth rate of grass in the various months of the growing season at various nitrogen applications (0, 20, 40, 60, 80 and 100 kg per cut per ha).

The amount of dry matter present on 1 May, 6 May, etc. could now be calculated (Table 3).

The number of growing days required to obtain grass for grazing or grass for silage or hay was calculated for the months after May. Grazing on 1 July will take growing days in June and possible in May, likewise cutting on 1 July (see Table 4).

Based on the relation dry matter yield/quality, expressed in terms of starch equivalent, the gross starch equivalent yield per cut was calculated. The net starch equivalent yield per cut is found by subtracting the losses occurring in grazing and conserving (Anon., 1967).

Table 3. Amount of dry matter present on several dates.

Nitrogen applied (kg/cut/ha)	Dry matter (kg/ha) present on			
	1 May	11 May	21 May	1 June
20	675	1250	2150	3150
40	825	1525	2675	3825
60	975	1900	3150	4400
80	1050	2175	3525	4875
100	1100	2370	3850	5330

Table 4. Growing days needed for grazing and cutting.

	Date of grazing or cutting	Nitrogen applied (kg/cut/ha)	Growing days needed in		
			July	June	May
Grazing	1 July	20	0	30	0
	1 July	40	0	26	0
	1 July	60	0	24	0
	11 July	20	11	20	0
	11 July	40	11	16	0
	11 July	60	11	14	0
Cutting					
(4 ton DM/ha)	1 July	60	0	30	11
	11 July	60	11	30	2

In this way a great number of data are obtained indicating the net starch equivalent supply of grassland in the course of the growing season. Naturally, the difference in growth rate in spring and summer was also taken into account. This is expressed, e.g. in the number of growing days required for grass for grazing, silage or hay.

Harvesting on 15 May and applying nitrogen on 16 May, one can obtain grass for grazing (1.7 ton dry matter) with: 20 kg N/ha in 29 days; 40 kg N/ha in 25 days; 60 kg N/ha in 22 days; and grass for silage (= 3 ton dry matter) with: 40 kg N/ha in 37 days; 60 kg N/ha in 33 days; and 80 kg N/ha in 30 days. However, if the harvest date is on 31 July and nitrogen is applied on 1 August, the number of growing days for grass for grazing is: 35 days with 20 kg N/ha; 30 days with 40 kg N/ha; and 28 days with 60 kg N/ha; and grass for silage is: 49 days with 40 kg N/ha; 45 days with 60 kg N/ha; and 42 days with 80 kg N/ha.

Grassland supply is opposite to animal requirements; on the one hand, the requirement of pasture grass, on the other hand, that of hay and silage during the housing period. The herbage is converted into value by the animals via milk and meat yield. Given a certain labour supply and a certain labour requirement of all activities, the ultimate problem is: What farm management will yield the highest gross profit and what yield pattern belongs to it? In this instance only the last question is relevant.

The results of programming for the yield patterns are mentioned in Fig. 2, 3, 4. In Fig. 2 the vertical axis shows the percentage of the total yield obtained in the months May through October; the horizontal axis shows various farm situations, e.g.:

Situation I

Usual management: pasturing from 1 May until 1 November; on 13 May the first cut is mown, harvesting is continued until 15 September.

I.10 – 10 ha, stocking rate 2.2 c.u./ha

I.15 – 15 ha, stocking rate 2.2 c.u./ha

I.20 – 20 ha, stocking rate 1.7 c.u./ha

Situation II

Pasturing period from 1 May until 1 November; cutting from 21 May until 23 August. Compared to I a shorter harvesting period.

II.10 – 10 ha, stocking rate 3.0 c.u./ha

II.15 – 15 ha, stocking rate 2.0 c.u./ha

II.20 – 20 ha, stocking rate 1.6 c.u./ha

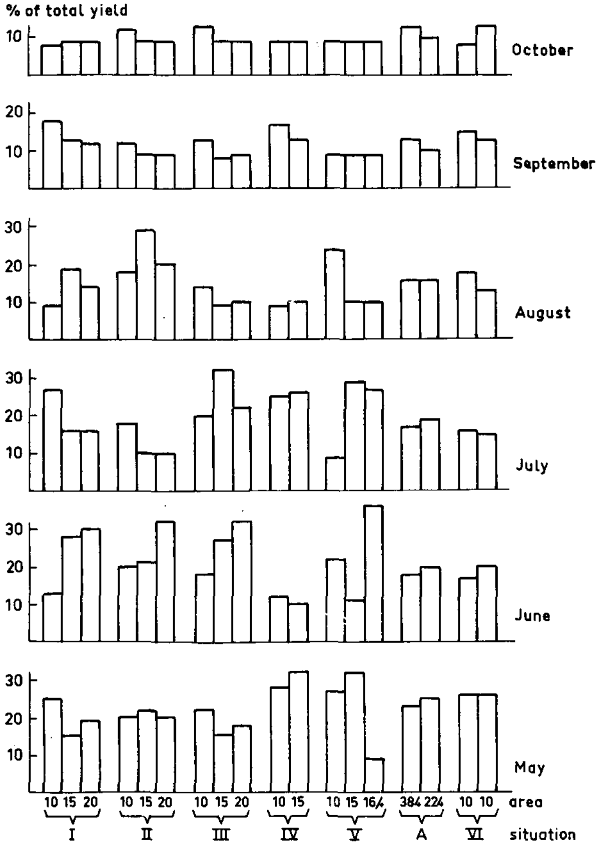

Fig. 2. Yield pattern of various farm situations. For explanation see text.

Situation III
As situation II, but the harvesting period is still shorter; from 13 May until 1 August.
III.10 – 10 ha, stocking rate 3.4 c.u./ha
III.15 – 15 ha, stocking rate 1.9 c.u./ha
III.20 – 20 ha, stocking rate 1.6 c.u./ha

Situation IV
A management in which the cattle are put to pasture on 1 June, while the first cut is completely mown. Harvesting can be continued until 15 September.
IV.10 – 10 ha, stocking rate 2.3 c.u./ha
IV.15 – 15 ha, stocking rate 2.1 c.u./ha

Situation V
As situation IV, but with a harvesting period until 23 August.
V.10 – 10 ha, stocking rate 2.3 c.u./ha
V.15 – 15 ha, stocking rate 2.1 c.u./ha
V.16.4 – 16.4 ha, stocking rate 1.9 c.u./ha

Situation A
These are the yield patterns belonging to a maximum yield (see page 60). Left the yield pattern of the entire 384 ha, right that of the 224 ha only cut for the drying plant.

Situation VI
A farm management not included in the programming. On the one hand, 10 ha with a stocking rate of 2.5 c.u./ha, on the other hand, 10 ha with a higher stocking rate, viz 3.0 c.u./ha.

Fig. 2 shows that one yield pattern is out of the question. Each farm situation has its own yield pattern. In the situations I, II, and III the June yield increases with an increasing grassland acreage. This is due to nitrogen application decreasing with an increasing acreage and at the same time a greater part of the mown acreage being flail harvested, because this is a labour saving method. With flail harvesting the herbage is cut at an older stage than for hay and wilted silage. The lower nitrogen application and the older growth stage result in a larger area being cut in the first part of June. In the situations II.10 and III.10 the yield pattern is 'fairly level': in II.10: 20, 20, 18, 18, 12 and 12; in III.10: 22, 18, 20, 14, 13 and 13. In these situations the stocking rate is rather high: 3.0 and 3.4 cattle units per ha, respectively, which is associated to a rather low cutting percentage: 76 and 62%, respectively. It is quite possible that decreasing the cutting percentage is associated with levelling the yield pattern.

The high yield percentages in May occurring in the situations IV, V.10 and V.15 are the result of the first cut being completely mown. In situation V.16.4 the yield is mainly harvested in June.

A final comment on Fig. 2 is that the yield pattern belonging to the maximum grassland yield (situation A) does not deviate from that in the situations I, II and III.

To investigate whether there is any relation between the yield percentages obtained in the various months, the percentages of two succeeding months were plotted against each other in Fig. 3.

Fig. 3 shows a negative correlation between the yield percentages obtained in May and June. This is due to a greater part of the first cut being harvested in May, by which the part harvested in June will be proportionally smaller and the reverse. In the months of May and June the first cut plays an important part.

The yield percentages of June and July are not or hardly correlated, but there is again a negative correlation between those of July and August. The interpretation of these results, however, is not so easy. Maybe some imperfection in the model is re-

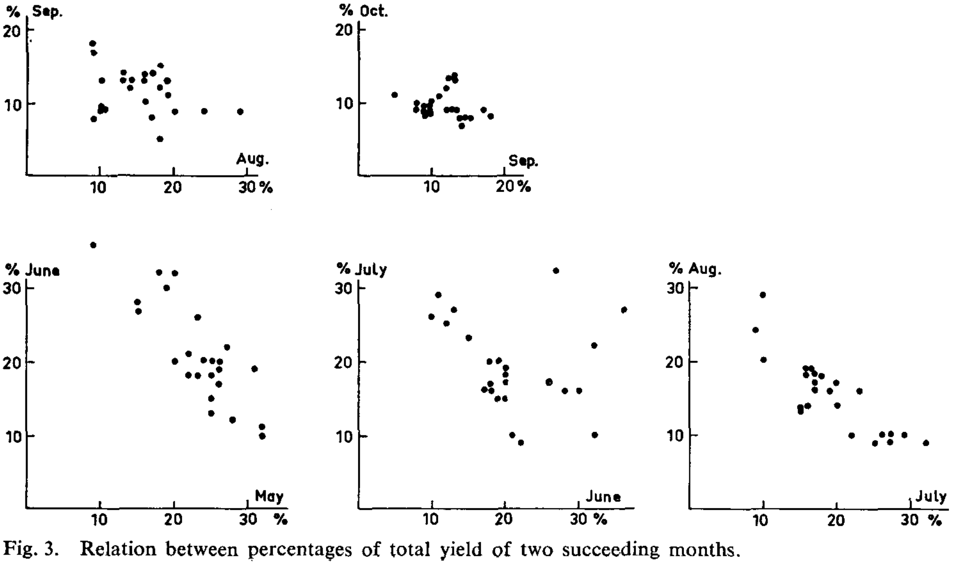

Fig. 3. Relation between percentages of total yield of two succeeding months.

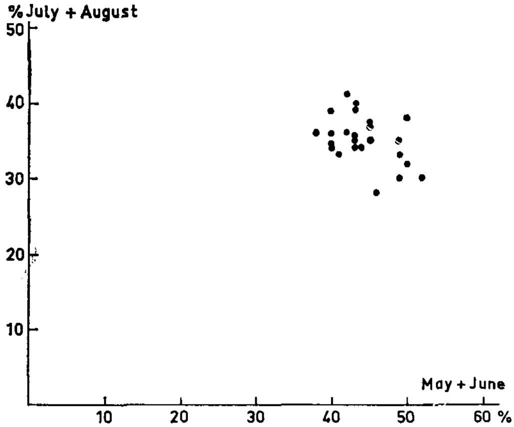

Fig. 4. Relation between percentages of total yield of May + June and July + August.

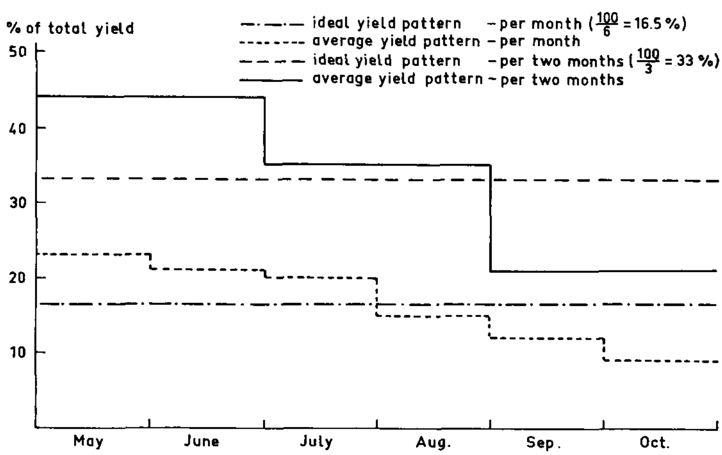

Fig. 5. Yield pattern: ideal and actual.

sponsible for the yield percentages of June and July being not or hardly correlated. The negative correlation between the yield percentages of July and August means again that the higher the harvest in July, the lower that in August, and conversely. The word harvest may probably be replaced by cutting, since we may proceed from the assumption that grazing cattle will consume almost equal amounts of grass per month.

The yields of August and September and those of September and October are not correlated. This could be due to the very small amount cut in September, while nothing at all is cut in October.

Since the May and June yields are correlated as well as the July and August yields and because those of June and July are not correlated or hardly so, the May and June yields were plotted against those of July and August (Fig. 4).

A striking feature in this figure is the rather small variation in yield percentages. In May + June the yield averages 44%, within a range of 38 (situation I.10) to 52%

(situation II.20). Yield in July + August averages 35 % within a range of 28 (situation VI.10.3) to 41 % (situation III.15).

Thus 79 %, on the average, of the yield is obtained in the months of May through August, of which 44 % in May and June (= 55.7 % of 79) and 35 % in July and August (= 44.3 % of 79). In the months of September and October another 21 % of the yield is harvested. If the yield pattern should have been a completely levelled one, 33 % of the yield should have been harvested per two months.

The higher yield percentage in May and June is obtained at the expense of that in September and October (Fig. 5).

Summarizing it may be stated that the preliminary results of this programming show that under optimum management in the various farm situations, a production pattern is found showing a top in May and June in all cases, indicating that spring growth is indeed turned to profit.

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