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Economic Aspects of Mechanization on Medium-sized Farms

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By K. BLECHSTEIN

Institut für landwirtschaftliche Arbeitswissenschaft und Landtechnik, Bad Kreuznach

POSSIBILITIES OF RATIONALIZATION IN AGRICULTURE

APPROXIMATELY half the production costs in agriculture are represented by direct labour (i.e. wages and cost of draught power). Thus, all measures taken to reduce labour requirements are extremely important. In this respect the greatest attention is paid at present to mechanization, which has to be considered as a *technical* measure of rationalization. As any type of mechanization requires considerable investment, however, it can seldom be undertaken by farmers who are short of capital resources. Even where the necessary capital is available, the costs of running the machinery have to be met. It is found quite often that, despite the reduction in labour requirements and the savings in wages, mechanization results in an increase in total costs.

Labour requirements are determined not only by the degree of mechanization (and the operations it makes possible) but by the whole organization of the farm, i.e. by the proportion in which different crops share in the total area of cultivation (LN)[1] and livestock carried per hectare. As opposed to increases in mechanization (i.e. the *technical* rationalization of the farm) changes in farm organization (i.e. the *economic* reorganization of the farm) alter production costs either not at all or only insignificantly. Before deciding on an increase in mechanization, therefore, the possibility of reorganizing the farm should first be thoroughly investigated. This paper deals with the relationship between farm organization and labour requirements. As any change in organization necessarily results in a change of income, this question too must be taken into account before, finally, the economic possibilities of mechanization are determined.

A. *The problems involved*

1. *Labour costs.* Approximately 50 working hours of a two-horse team are needed per annum for the planting, cultivating, and harvesting of one hectare of cereals. Assuming 2,500 working hours per annum, one team of horses should be sufficient to work 50 ha. of

[1] A glossary of the symbols used in this article will be found on p. 51.

cereals. A 50-ha. holding which is exclusively devoted to cereals, however, uses a considerably greater number of horse-teams. The reason is that the 50 team hours per ha. of cereals are restricted to a few periods of the year which are strictly limited by growth and climate, the *time-period.* Thus of the 2,500 team hours in the example, autumn cultivation alone accounts for 1,000 hours. As during this period roughly 50 working days are available, 20 hours would have to be worked in the course of each day, a number of hours which it is impossible for one team of horses to achieve.

Generally it follows that farms which cannot obtain draught power (*ZK*) from outside must maintain sufficient of their own to meet their needs during the period of highest requirements. This maximum requirement may be called the 'draught-power peak'. This period put in relation to the whole year represents the draught-power costs of the farm.

The requirements of human labour (*AK*) also vary with different seasons. The requirement for regular labour need not agree exactly with the labour peak because nearly every farm can employ casual labour when necessary. Thus the requirement for regular labour is reduced by that amount of casual labour which it is possible to employ during the peak period. The costs for regular and casual labour can thus be calculated and these together with the costs of draught power represent the total direct labour costs of the farm.

The following question must therefore be answered: What effect has the organization of the farm upon the cost of labour?

2. *The net profit.* A grassland holding with only a small amount of cultivation will have low labour requirements and therefore low costs of labour. This type of organization could thus be regarded as an answer to the first question.

This type of holding, however, has a very low income so the investigation must deal also with the influence of farm planning on its economic success. From this follows the second question: What effect has the organization of the farm on the net profit?

3. *Economic limits to mechanization.* The discussion so far has been concerned with a certain stage of mechanization, 'a', which will be more closely defined below, under section B. In certain circumstances it is possible to reduce harvest losses by increased mechanization (stages b, c, d, e), and to increase yields slightly by better cultivation of the soil. If these rather dubious and insignificant possibilities be

disregarded, neither income nor outlay will be greatly affected by these stages of mechanization. The cost of labour, however, is reduced while the costs for amortization, interest, and maintenance of the machines are increased. If, therefore, the net profit is not to be reduced by the process of mechanization, the additional annual costs of machinery must not exceed the savings due to the reduction of labour costs. In order to judge the economic limits of increasing mechanization, therefore, the following question arises: By how much can increased mechanization reduce the cost of labour in the most favourable circumstances?

B. *The starting-point*

The investigations concern farms which have two horses, which cultivate potatoes as the sole root crop for sale, and which neither practise intercropping nor cultivate sugar-beet. The *constants* are:

influence of manager and labour,
the condition of the labour market, i.e. the possibility of employing casual labour (during the hay harvest with 33⅓ per cent., during the harvest of late cereals with 50 per cent., and during the beet harvest with 100 per cent. of the regular labour force),
type of animal husbandry (cattle, pigs, and horses),
the purpose for which cattle are kept (self-contained milking herd; summer pastures for young cattle only),
the use of potatoes (50 per cent. for feeding pigs, remainder used as seed potatoes for own use and for eating purposes),
mechanization stage 'a' (corn drill, *Vielfachgerät*,[1] self-binder, rotor-tiller), or, as assumed for the investigation of this problem, mechanization stages b, c, d, and e.

The following are also uniformly assumed:

30 dz. cereals per ha.[2]	260 dz. potatoes per ha.
65 dz. hay per ha.	650 dz. fodder beet per ha.
40 DM. per dz. cereal[3]	25 DM. per dz. milk
10 DM. per dz. eating potatoes	180 DM. per dz. beef
220 DM. per dz. pork	

37·3 dz. protein basic fodder[4] per cow unit (*GVE*)[5]

[1] An implement used in Germany mainly for the cultivation of potatoes and beet.

[2] 1 dz. (doppelzentner) = 220·5 lb. 1 dz. per ha. = approximately 0·8 cwt. per acre.

[3] £1 = 11·70 DM. = $2.80 (approximately), early 1954.

[4] Protein basic fodders are summer-green fodder, hay, and protein silage. Accordingly, the protein basic fodder acreage (*EGF*) consists of the sum of meadows, pastures, clover, lucerne, &c. The common denominator is hay: 5 kg. green fodder or 3 kg. protein silage = 1 kg. hay.

[5] 1 *GVE* = 1 cow unit = livestock with the same fodder requirement as a 500 kg. cow with an annual milk production of 3,000 kg. 1 draught power unit = 0·6 *GVE*.

51·6 dz. carbohydrate basic fodder[1] per *GVE*
2·4 dz. concentrates per *GVE*
15·5 dz. additional concentrates per draught power (*ZK*)
11·8 dz. potatoes per dz. fat pig
1·7 dz. concentrates per dz. fat pig

For reasons of labour economy it is necessary to *vary* the proportion of early potatoes, and early cereals within the total potato and cereal acreages: 'proportion of early crops' I, II, and III.

C. *The Method*

1. *Definition of acreage and livestock numbers.* Both the labour requirements and the cost of labour, as well as all other expenses and income, are based on the individual farm acreages and livestock numbers. In order to investigate the problem, therefore, it is advisable to express these organizational factors through a few symbols. The following were chosen:

The share of the protein basic fodder acreage (*EGF*) in the total (*LN*) is expressed as b (the share of the 'remaining acreage' *RA* must consequently be $RA = 1-b$, for which b' will be used), and
the share of root crops h of the *RA* (as the remaining acreage carries only cereals apart from root crops, the share of cereals $= 1-h = h'$).

Thus the following organizational factors can be expressed by reference to b, h, and *LN* only:

(*a*) protein basic fodder acreage (*EGF*): $EGF = (b \times LN)$ ha. or in short, bLN ha.;
(*b*) root-crop acreage (*H*), comprising potato acreage (*K*) and fodder beet or carbohydrate basic fodder acreage (*KGF*): $H = hb'LN$ ha. $= K+KGF$;
(*c*) cereal acreage (*G*): $G = h'b'LN$ ha.

The remaining acreage and livestock numbers can be derived by using the fodder rations and yields given under section B above.

(*d*) Where the land is used by roughage-eating livestock (*R*):

$$R = \frac{bLN/\text{ha. } EGF \times 65 \text{ dz./ha. } EGF}{37{\cdot}3 \text{ dz./}GVE} = 1{\cdot}75\ bLN\ GVE;$$

[1] Carbohydrate basic fodders are the basic fodders of low protein content, e.g. fodder beet, mangolds, &c. The calculation is only done on the basis of fodder beet. Accordingly the carbohydrate basic fodder acreage (*KGF*) is identical with the fodder-beet acreage.

(*e*) carbohydrate basic fodder acreage (*KGF*):

$$KGF = \frac{1{\cdot}75\ bLN\ GVE \times 51{\cdot}6\ \text{dz./}GVE}{650\ \text{dz./ha.}} = 0{\cdot}14\ bLN\ \text{ha.};$$

(*f*) potato acreage (*K*) as the difference between root acreage (*H*) and *KGF* as secondary root acreage:

$$K = hb'LN - KGF = (hb'LN - 0{\cdot}14\ bLN)\ \text{ha.};$$

(*g*) where the land is used by fattening pigs (*S*):

$$S = 11{\cdot}0\ K = (11{\cdot}0\ hb'LN - 1{\cdot}54\ bLN)\ \text{head per year.}$$

In the following individual investigations the share of protein basic fodder acreage in *LN* is kept constant at $b = 0{\cdot}20$. The share of root crops (*h*) in the remaining acreage, however, will be varied between $h = 0{\cdot}20$ and $h = 0{\cdot}40$. As examples, figures for farms with $h = 0{\cdot}40$ (farm A), 0·36 (farm B), and 0·20 (farm C) have been calculated. For farm A the three stages of mechanization a, b, and c (farm Aa, Ab, Ac) and for farm C the stages of mechanization a, d, and e (farm Ca, Cd, Ce) will be discussed in greater detail.

2. *The cost of labour.* Dealing here with method only, the costs for the regular labour force will be ascertained. To do this it is necessary to calculate the requirements for regular labour.

According to section A (1) above, it should suffice to calculate the *AK* requirements for the respective peak period for the different possible types of farm organization. For farms where cereal growing prevails, this is the time of the late cereal harvest. For farms where root-crop cultivation prevails, it is the time of root-crop harvest, and for farms which concentrate on growing forage crops, it is the time of hay harvest and beet cultivation. On some types of farm, even spring cultivation may represent the *AK* peak. It is impossible to recognize at first glance the 'time-period', when the *AK* peak will occur for any given type of farm organization. For this reason it is necessary to calculate the *AK* requirements for each time-period and each type of organization. They are derived from the hectare labour requirements for the seasonally required work for different crops and from their share in the *LN*; to this must be added the *AK* demands of livestock. Using the formulae given under section C (1) for acreage and livestock numbers, a very simple equation is found for the requirements of regular *AK* for the individual time-periods. For the daily requirements of *AK* during the period of the potato harvest (subsequently referred to as period 7), in the case of mechanization stage 'a', and

assuming that the share of early potatoes (I) is 10 per cent. of the total potato acreage, the equation is:

$$\text{Regular } AK_{\,7\text{Ia}}/100 \text{ ha. } LN = 6{\cdot}8 + 94{\cdot}9\,hb' + 7{\cdot}2b.$$

If on the other hand no early potatoes are cultivated (share of early potatoes III) this value is increased to:

$$\text{Regular } AK_{\,7\text{IIIa}}/100 \text{ ha. } LN = 6{\cdot}8 + 105{\cdot}1\,hb' + 5{\cdot}8b.$$

If it is desired—and it is necessary for these investigations—to determine the AK requirements for different types of farm organization, it is best to use the graphical method shown in Fig. 1, which is applicable to those farms with a protein basic fodder acreage of $b = 0{\cdot}20$. The value 0·20 can now be substituted for b and 0·80 for b' in the above equations:

$$\text{Regular } AK_{7\text{Ia}(b\,=\,0{\cdot}20)}/100 \text{ ha. } LN = 8{\cdot}3 + 75{\cdot}8\,h \text{ and}$$
$$\text{Regular } AK_{7\text{IIIa}(b\,=\,0{\cdot}20)}/100 \text{ ha. } LN = 8{\cdot}0 + 84{\cdot}1\,h.$$

Two straight lines 7I and 7III are drawn in Fig. 1. They represent regular AK/100 ha. LN required by share of root-crop acreages h ranging from 0·20 to 0·40. In the same way different straight lines are determined for the periods 4 (early cereal and early potato harvest) and 5 (late cereal harvest) depending on the proportion of early potato and early cereal acreages. These proportions have little or no effect on the period 2 (spring cultivation), 3 (hay harvest), and 6 (second hay crop) so that in Fig. 1 only the straight lines 2, 3, and 6 appear.

In the case of a root-crop acreage of $h = 0{\cdot}40$ (farm Aa) the harvest of the root crops undoubtedly determines the regular AK requirements. In order to manage with few regular AK, this type of holding will cultivate the above-mentioned 10 per cent. early potatoes—this figure having been assumed as the upper limit of early potato growing with regard to the limited market. This gives a requirement of 19·3 regular AK/100 ha. LN as shown by the straight line 7I. Further, this type of holding will endeavour to employ fully these 19·3 AK also in period 4 (early cereal and early potato harvest). Consequently the straight line 7I also illustrates the AK required during period 4. For this reason it is referred to as line 7I–4I. This demands in addition to the already mentioned early potato share I a certain early cereal share I. From this we obtain the straight line 5I for the AK requirements of period 5 (late cereal harvest) which with $h = 0{\cdot}40$ lies below the straight line 7I/4I. As also the straight lines 2 and

particularly lines 3 and 6 show lower *AK* requirements than the straight line 7I/4I, it is indeed the root-crop harvest and with it the straight line 7I/4I which determines the requirements of regular *AK* in the case of a farm of the type Aa.

The position is completely different with a root-crop share of $h = 0{\cdot}20$ (farm Ca). As this type has to deal with a great deal of cereals, period 4 will have to be relieved of any early potato harvest. Consequently, the straight line 7III is valid for period 7. Further an early crop acreage III will have to be chosen which leads to an equally high regular *AK* requirement in both periods of cereal harvest 4 and 5. This is given by the straight line 4III/5III.

With a root-crop acreage of $h > 0{\cdot}31$ it can be seen from Fig. 1 that with an early crop acreage III the *AK* requirement during period 7 (straight line 7III) exceeds that of the periods 4 and 5 (4III/5III). Similarly with $h < 0{\cdot}36$ the *AK* requirement during period 5 (line 5I) exceeds that of periods 4 and 7 (straight lines 7I/4I) when the early crop acreage I is retained. In this situation a proportion of early crops II is advisable. In this case we have the particularly favourable economic condition that their regular *AK* requirement is constant during the periods 4, 5, and 7; in other words regular labour can be fully and productively employed during all three periods: Straight lines 4II/5II/7II.

The heavy line 4III/5III–4II/5II/7II–7I/4I, in Fig. 1 gives, finally, the regular *AK* requirement for the different values of the root-crop proportions h for farms with protein basic fodder acreages of $b = 0{\cdot}20$.

Basically, the same rules apply for the relationship between type of farm organization and the requirement for additional *AK* or *ZK* respectively. They need not, therefore, be elaborated.

In order to determine the labour costs, it is necessary to multiply the three figures for regular and additional *AK* as well as *ZK* by the annual costs for *AK*, &c. Their sum gives the total direct labour costs in DM./ha. *LN* and is shown in Fig. 2 by the heavy line for $b = 0{\cdot}20$. The other curves represent labour costs for $b = 0{\cdot}10$, $0{\cdot}30$, $0{\cdot}40$, and $0{\cdot}50$.

3. *The net profit.* The net profit of a farm is the difference between the monetary value of the produce—the gross income—and the expenses incurred. The gross income depends, apart from the yield and price of the produce, only on the allocation of acreages to various crops and the livestock numbers. The same can be said with sufficient

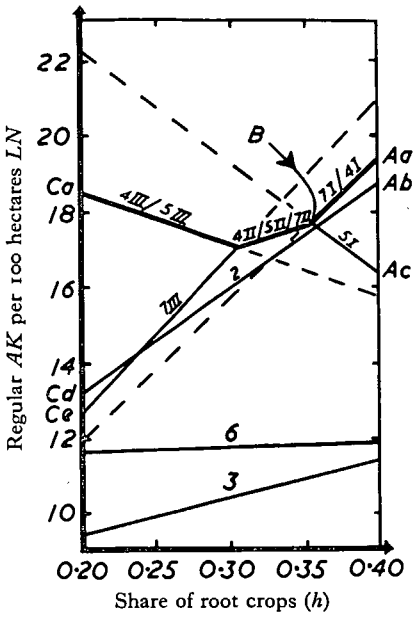

FIGURE 1. Regular labour requirement (AK) with varying share of root crops (h)

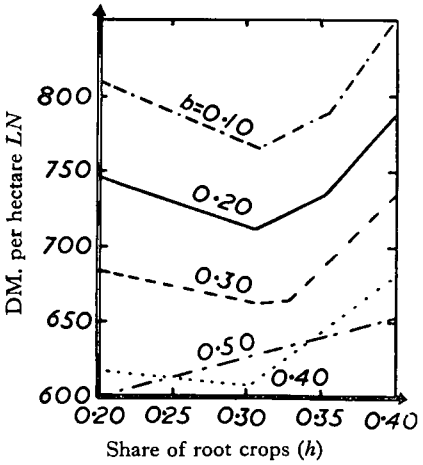

FIGURE 2. Direct labour costs for different types of farm organization

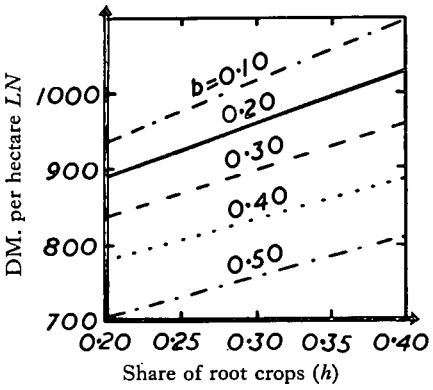

FIGURE 3. Provisional surplus for different types of farm organization

accuracy also for all expenses with the exception of direct labour costs. The first two-mentioned items in the account can be simply expressed by means of the symbols h and b. The difference between them, which is called 'provisional surplus $\dot{U}$/ha. LN', amounts to[1]

$$\dot{U}/\text{ha. } LN = 810+874\,hb'-313\,b,$$

as shown in Fig. 3 for all cases investigated.

Fig. 4 expresses the surplus in column form for the three farms Aa, Ba, and Ca with 1,027, 996, and 887 DM./ha. LN respectively.

The direct labour costs as given in Fig. 2 with 789, 734, and 746 DM./ha. LN respectively have also been incorporated into Fig. 4 and are represented by the black portions of the individual columns. Thus the white portion of the columns gives the net profit with 238, 262, and 141 DM./ha. LN respectively.

For the direct relationship between type of organization and net profit the reader is referred to Fig. 5.

To facilitate comparison in Fig. 4, the amount of the net profit B has been drawn as a dotted horizontal line across the whole of the diagram. Thus the black portions of the columns below this line of comparison (B) represent the difference in net profit for farms of the type Aa, Ba, and Ca respectively.

4. *Reduction of labour cost through mechanization.* If one type of work is mechanized, the requirements of AK and ZK necessary for it

[1] The author explains his use of 'Ü' as follows: Der Ausdruck 'vorläufiger Einnahmeüberschuss Ü' ist selbst im Deutschen nicht korrekt (den Begriff als solchen gibt es übrigens auch bei uns nicht). Er soll aber eine Rechengrösse kennzeichnen, die die Geldrechnung sehr vereinfacht. Hierzu folgende Erläuterung:

Der 'Reinertrag a' ergibt sich aus dem 'Rohertrag b', d. h. dem Wert der geernteten Früchte bzw. der aus ihnen erzeugten tierischen Nahrungsmittel, wenn man von dem Rohertrag b die 'gesamten Ausgaben c' abzieht. Diese Ausgaben nun sind zum Teil den Einnahmen b direkt proportional. Bei meiner Rechnung können Sie also von vornherein von den Einnahmen b abgesetzt werden. Diesen Teil der Ausgaben bezeichne ich mit 'd'.

Die anderen Ausgaben, das sind die Löhne und die Zugkraftkosten, habe ich Arbeitskosten e genannt. Sie sind nicht mehr dem Aufwand proportional sondern gehorchen anderen Gesetzen, wie sie in der Darstellung 2 zum Ausdruck kommen.

Zusammenfassend lässt sich jetzt ausdrücken:

1. $a = b-c$
2. $c = d+e$
3. $a = b-d-e$
4. $b-d = f$
5. $c = f-e.$

Diese 'Zwischengrösse f' ist es, die ich 'vorläufiger Einnahmeüberschuss Ü' genannt hatte. Vielleicht wäre es richtiger, sie in deutsch einfach mit 'Rohertrag II'=englisch 'gross income II' zu nennen, während die Grösse b als 'Rohertrag I'='gross income I'— bezeichnet wird.

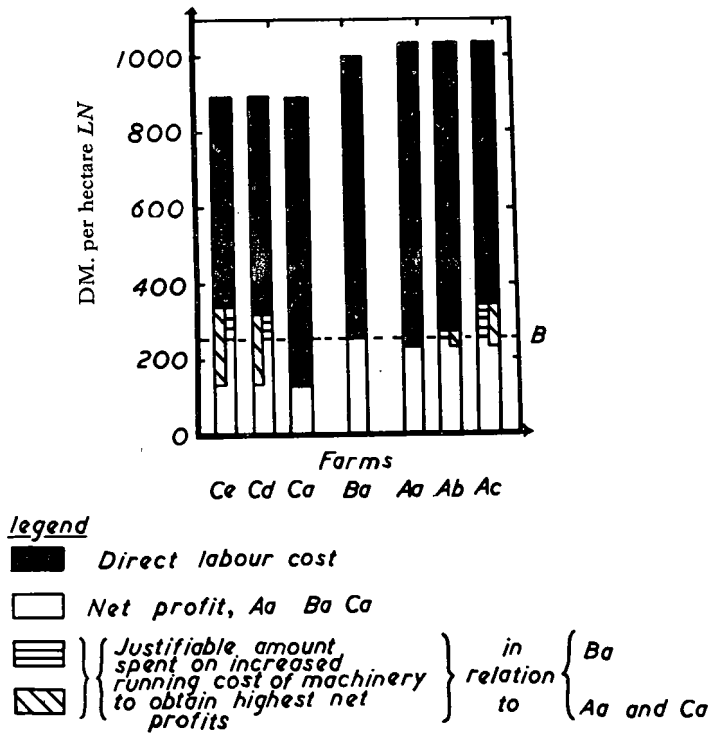

FIGURE 4. Limits to mechanization

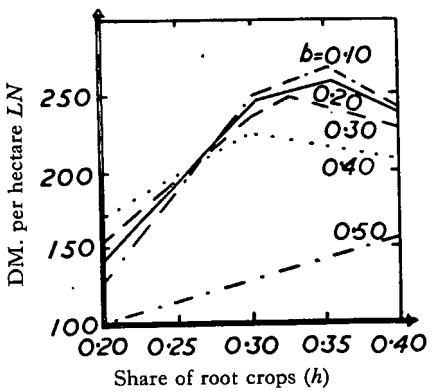

FIGURE 5. Net profit for different types of farm organization

are usually reduced for the whole period during which this type of work is carried out. The number of regular *AK* and *ZK* required for the whole farm, however, changes only if the season in question determined the regular *AK* and *ZK* requirements, i.e. if it included the farm labour peak. In this case, after mechanization has been carried out, regular *AK* and *ZK* requirements—and with them the costs of labour—are determined by whichever is the next higher peak. The resulting reduction in labour costs is the maximum amount to which the annual machinery costs may be increased. The peak period for farm Aa is, according to Fig. 1, determined by the root-crop harvest. For this type of farm, therefore, mechanization of the root-crop harvest—mechanization stage b—would have to be considered first: farm Ab. Thus on such a farm regular labour requirements are no longer determined by period 7, but by the next higher period, in this case period 2. According to Fig. 1 the farm now requires only 18·7, while Aa required 19·3 *AK*/ha. *LN*. The equivalent labour costs have been entered in black in the Ab column of Fig. 4 (which because of its identical provisional surplus $\dot{U}$ must have the same height as column Aa) and now amount to only 753 DM./ha. *LN*.

The next higher stage of mechanization, c, must accordingly reduce the labour requirements during spring cultivation. This is achieved by mechanizing potato cultivation which is the most labour-consuming type of work during period 2. For this case—farm Ac—the remaining labour costs have been shown in the black portion of Fig. 4. According to Fig. 1 they are determined by the labour requirements during period 5.

If it is intended to mechanize rationally farm Ca (with $h = 0{\cdot}20$) it is necessary to start by mechanizing the cereal harvest—again in accordance with the straight lines showing regular labour requirements in Fig. 1. This stage of mechanization, d, makes the farm into type Cd. Here the next step would also be mechanization of the potato cultivation, as in accordance with Fig. 1 the straight line 2 is the next higher after line 4C/5C. This gives farm Ce with mechanization stage e. Corresponding columns have been drawn in Fig. 4 for these two farms.

D. *Preliminary results*

Using the above method, the values necessary to answer the questions mentioned at the beginning of this paper were calculated for farms with

Protein basic fodder proportions b on LN of 0·10, 0·20, 0·30, 0·40, and 0·50 as well as root-crop share h on the remaining acreage RA between 0·20 and 0·40.

As the investigation of the problems involved is still in progress, the results must be regarded as preliminary, particularly as they are applicable only under the conditions stipulated in section B.

1. *Labour costs.* The cost of labour/ha. LN is shown in Fig. 2 in five lines for five different values of b relative to the root-crop proportion h. The graph for $b = 0{\cdot}20$ agrees closely with the line showing regular AK requirements in Fig. 1. The explanation of this given in section C (2) is therefore also applicable to the graph showing labour costs for $b = 0{\cdot}20$; for the line $b = 0{\cdot}10$ the same rules are valid. The rise of the $b = 0{\cdot}30$ graph beginning at approximately $h = 0{\cdot}33$ is explained by the fact that with this value for b the labour peak for higher root-crop shares no longer falls into the period of the root-crop harvest, but into that of spring cultivation. The graph for $b = 0{\cdot}40$ is determined only by the labour peak of the cereal harvest or spring cultivation respectively. The graph for $b = 0{\cdot}50$ results from the fact that with such a protein basic fodder share the labour peak is determined by the period of the hay harvest in every case, no matter what the root-crop share is.

The following conclusions can therefore be drawn as to the relationship between farm organization and labour costs:

(*a*) labour costs and protein basic fodder share b.

The graphs for $b = 0{\cdot}20$ and particularly those for $b = 0{\cdot}30$ and 0·40 lie, whatever the root-crop share, considerably below that for $b = 0{\cdot}10$. The reason for this is that with increasing b the cereal and root-crop acreages correspondingly decrease. As with such b values the labour peak always depends on the latter acreages, labour costs decrease in accordance with their values; on the other hand, the increase in labour requirements during the period of the hay harvest, which coincides with an increase in the value of b, is still unimportant, as up to $b = 0{\cdot}40$ the hay harvest in no case becomes a labour peak.

The picture changes, however, at a value of $b = 0{\cdot}50$. Here the cultivation of fodder has become so considerable that the hay harvest period becomes the labour peak, whatever the root-crop share. The graph for $b = 0{\cdot}50$ thus becomes a straight line whose shape is determined only by the labour

requirements of the hay harvest and root-crop cultivation, period 3.

It can be concluded from these calculations that the enterprise, 'Fodder growing associated with livestock husbandry', will have a balancing effect on labour organization up to a value of approximately $b = 0{\cdot}40$.

(*b*) labour costs and root-crop share *h*.

The shapes of the graphs for $b = 0{\cdot}10$ and $0{\cdot}20$ show similar relationships. In spite of the fact that labour requirements for 1 ha. of the root crop doubtless exceed those for 1 ha. of cereals, labour costs fall from values of $h = 0{\cdot}20$ to $h = 0{\cdot}31$; only from this point on do they show an increase.

In this case also there is a balancing effect on labour organization between root-crop and cereal growing.

The conclusions to be drawn from Fig. 2 for the cost-of-labour question can be summarized thus:

A change in labour organization alone can reduce labour costs considerably—in extreme cases by as much as 25 per cent.

2. *The net profit.* The net profit is the difference between the 'provisional surplus $\dot{U}$/ha. *LN*' (Fig. 3) and the labour costs (Fig. 2).

A comparison of these two graphs for identical values of *b* shows a reduction in labour costs with an increasing *b*, but a simultaneous decrease in $\dot{U}$. From this it follows in Fig. 5 for protein basic fodder shares between $b = 0{\cdot}10$ and $0{\cdot}40$, that the net profit does not vary greatly with varying *b*. For $b = 0{\cdot}50$, on the other hand, there must be an extremely low net profit as here the labour costs are almost identical with those for $b = 0{\cdot}40$, while $\dot{U}$ is considerably reduced.

Contrary to *b*, the root-crop share *h* has a strong effect upon the net profit. While $\dot{U}$ increases in the same way as *h*, labour costs, as explained in section D (1), do not alter in conformity with the root-crop acreage. In the final analysis the highest net profits are found, therefore, at $b = 0{\cdot}10$ to $0{\cdot}40$ in accordance with the root-crop shares with the lowest labour costs.

The answer to the net-profit question is therefore that a reasonable change in farm organization is capable of rationalizing the whole farm enterprise; the lowest net profit lies 62 per cent. below the highest net profit.

3. *Economic limits to mechanization.* In accordance with the above considerations mechanization is economic only if the annual increase in the cost for machinery does not exceed the saving arising from the reduction of labour costs.

It is seen from Fig. 4 that at 753 DM. the labour costs of farm Ab lie 36 DM./ha. *LN* below those of farm Aa (vertically hatched portion of the column). If the annual machinery costs were thus increased by 36 DM./ha. *LN*, both farms would balance their accounts with a net profit of 238 DM./ha. *LN*.

As it is, their net profit lies 24 DM. below that of farm B. For farm A the mechanization stage b would only be preferable to a change to type B if the annual machinery costs increased by only $36 - 24 = 12$ DM./ha. *LN* (horizontally hatched portion of the column). In every other case the change to farm type Ab will lead to a smaller net profit than a change to type B.

For mechanization stages c, d, and e the marginal values can be read from the horizontally hatched portions of the columns with 75, 63, and 88 DM./ha. *LN* respectively.

The most promising mechanization stage is probably represented by stage Ac. For a farm of 15 ha. *LN* the annual machinery costs may, with greater mechanization of root-crop harvest and potato planting, be increased by $15 \times 75 = 1{,}125$ DM. For the mechanization of the cereal harvest, on the other hand, a 15-ha. farm would have available only $15 \times 63 = 945$ DM. From this it follows that prior to any technical rationalization by mechanization it is necessary to make full use of all possible economic rationalization by farm reorganization.

GLOSSARY

AK = Human labour
B = Net profit
b = Share of protein basic fodder acreage in the total area
EGF = Protein basic fodder acreage
G = Cereal acreage
GVE = Cow unit
H = Root-crop acreage
h = Share of root crop in the remaining acreage
K = Potato acreage
KGF = Carbohydrate basic fodder acreage
LN = Total area of cultivation
R = Roughage-eating livestock
RA = Remaining acreage
S = Fattening pigs
$\dot{U}$ = Provisional surplus (see footnote, p. 46)
ZK = Draught power

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