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PROCEEDINGS
OF THE
SECOND INTERNATIONAL CONFERENCE
OF
AGRICULTURAL ECONOMISTS

HELD AT
CORNELL UNIVERSITY,
ITHACA; NEW YORK,
AUGUST 18 TO AUGUST 29, 1930

The Collegiate Press
GEORGE BANTA PUBLISHING COMPANY
MENASHA, WISCONSIN

1930

Indexed

4 cards
Germany. Farm labor
Research. Farm labor
Farm labor. Germany

METHODS AND RESULTS OF RESEARCH WORK ON THE EFFICIENCY OF HUMAN LABOR ON GERMAN FARMS

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FARM cost accounts covering a period of one hundred years or more show that the cost of human labor represents from 25 to 50 per cent of the total cost of production on German farms. In view of this fact it is surprising that we have not given more attention to the study of scientific methods for increasing the efficiency of this important factor. It is true that Albrecht Thaer and Johann Heinrich von Thuenen who were among the earlier writers in Germany on matters pertaining to agriculture, emphasized the importance of the effective utilization of farm labor. Von Thuenen, as a matter of fact, developed a mathematical formula for use in determining wage scales for agricultural laborers, which he deemed of sufficient importance to have engraved on his tombstone.

As the science of agriculture developed, however, interest centered on research in plant industry, agricultural chemistry, animal husbandry, animal nutrition, and so forth, and little or no attention was given to research in methods for increasing the efficiency of labor. The development of improved farm machinery appeared to solve the major labor problems. Only the agricultural economist gave the labor question any consideration, and his approach was wholly from the economic point of view.

Scientific studies of labor in industry have been made in the United States by Frederick Winslow Taylor and others. I first became acquainted with this work through the writings of Hugo Muensterberg, a fellow countryman of mine who has taught for many years in your universities. It seemed to me that Taylor's theories and those of his followers could be applied to advantage in devising ways and means for increasing the efficiency of farm labor. I tried to develop this idea in a paper written in 1919 at a time when German agriculture was in great distress, and when the ability of her people to work appeared to be the principal resource remaining to Germany.¹ I suggested that an in-

¹ Seedorf, J. J. W. Die Vervollkommnung der Landarbeit und die bessere Ausbildung der Landarbeiter unter besonderer Berücksichtigung des Taylorsystems. Berlin, Deutsche Landbuchhandlung, 1919.

stitute be organized and that careful scientific investigations be made of all possible ways and means of increasing the efficiency of agricultural labor. This project was undertaken by the State of Saxony which founded an institute and an experimental farm for the study of this problem at Pommritz.

In general it may be said that we have applied the microscope to a study of the labor involved in various farm operations. A given operation is analyzed into its component parts, and careful time and motion studies are made of every element. The object of these studies is to find the most efficient way of performing each part of the operation. A method for performing the operation as a whole is then developed by combining the most effective means found for performing each of the various elements involved. Such methods of job analysis have long been effectively employed in German industry. However, the possibility of employing similar methods as a means of increasing the efficiency of labor in agriculture has been overlooked by German farmers, and as I have learned since coming here, by American farmers as well.

Little has been done in the way of standardizing labor operations. There are wide differences in the way in which the same farm operation is performed in different parts of Germany. This is true to a lesser extent in the United States. Some of these differences are due, of course, to differences in natural conditions of soil, climate, topography, and so forth. However, for the most part they appear to be largely due to the fact that farmers in the various parts of the country have merely become accustomed to performing a given task in a certain way, and continue to use the methods which their fathers used before them. It would appear that there is room for the development of a science of agricultural labor, which would have as its object the increasing of the efficiency of agricultural labor, and through increasing efficiency, the improvement of rural standards of living and the lowering of the costs of production of agricultural products.

Agricultural labor may be considered from the economic, the physical, or the social point of view. Agricultural economists have done a very considerable amount of work in Germany on the economic aspects of agricultural labor. Cost accounting in Germany is very common, and has been carried on for many years. Careful analyses have been made of the labor costs entering into the vari-

ous farm operations. In many of your own colleges excellent work is being done in this field. It may be said, however, that there is still room for further investigation along these lines.

Very little work has been done to date in studying the effect of various kinds of labor, or rather in studying the effect of the various motions involved in performing given types of labor operations, on the physical well-being of the laborer. Such studies will of necessity take us over into the fields of chemistry, physics, physiology, and other related sciences. Much work remains to be done in this direction.

Since the improvement of human welfare is the ultimate end of research work in all branches of science, we cannot overlook the importance of investigations into the social aspects of rural life. Considerably more progress has been made in this field in the United States than in other countries. Rural sociology is recognized as a special field for research, and courses in this subject are given in the majority of the agricultural colleges in the United States. Nothing of this sort has been done in Germany.

In making studies of the efficiency with which various farm operations are performed, the following factors must be considered:

1. The man.
2. The tools or machine used.
3. The type of soil, the class of crop, or the class of livestock with which he is working, and the climatic, economic, sociological, and political conditions under which he is working, and the mental attitude of the worker.

As previously stated, little has been done in attempting to determine the effect on the physical and mental well-being of the worker in performing a given kind of work. A great deal more investigational work needs to be done in this direction. We must borrow from the findings of workers in the other branches of science and apply the results to the solution of our problems.

In industry standardized methods of performing each operation, based upon careful time-motion-fatigue studies have resulted in greatly increased output per worker. Similar methods can be applied with equal effectiveness in agriculture. Let us analyze, for example, the operations involved in seeding grain with a grain drill. The time required to perform the drilling operation may be divided into the following component parts:

1. The time during which the machine is actually running.
2. The time required for turning.
3. The time required for refilling the machine.

The efficiency with which the machine is operated, measured in terms of actual accomplishment per unit of time, depends upon a number of factors such as the rate at which the machine is drawn by the tractor or horses, the time required for turning, the time required for refilling, and the amount of time, which for various reasons, is lost. The size and construction of the machine, soil conditions, the size and shape of the field, and the ability of the operator has, of course, an important bearing upon the work accomplished within a given time. The figures in table 1, which are based on a large number of investigations made near Göt-

Table 1. Results of Time and Motion Studies of Grain Drilling Operations On a Large Number of Farms Near Göttingen, Germany

	Range	Average
Rate of travel (meters per minute)	53-95	70
Time required for turning (minutes)	0.53-1.16	0.82
Time required for filling (minutes)	1.05-3.75	2.06
Distance traveled per hour of working time (meters)	2059-3629	3184

tingen, Germany, illustrate the variations existing in the time required to perform certain operations.

The effect of the length of the field upon the per cent of the total working time actually spent in drilling, is shown in figure 1. The drill was in actual operation approximately 80 per cent of the total working time in the fields 500 meters in length, while it was in actual operation only between 50 and 60 per cent of the time in the fields 100 meters in length. Stated in another way, the percentage of lost time, that is time spent in filling, turning, and so forth, was over twice as great in the short fields as in the larger ones.

The results of some of our studies are rather surprising. In plowing it is the practice on many farms in Germany to use both horses and oxen in the same field. Under such circumstances, of course, the slower moving oxen set the pace. Our studies showed that the number of acres plowed per day by four teams of horses and a team of oxen working in the same field was

actually less than the number of acres plowed per day by the same four teams of horses working alone (figure 2).

Nearly all types of farming operations requiring the use of human labor have been investigated in Germany during the past few years in some one of the various institutes. Dr. Derlitzki at Pommritz, and Dr. Ries at Bornim, have made studies of the labor operations in connection with the planting and harvesting of potatoes. A very considerable amount of work has also been done at Pommritz on the culture of sugar beets.

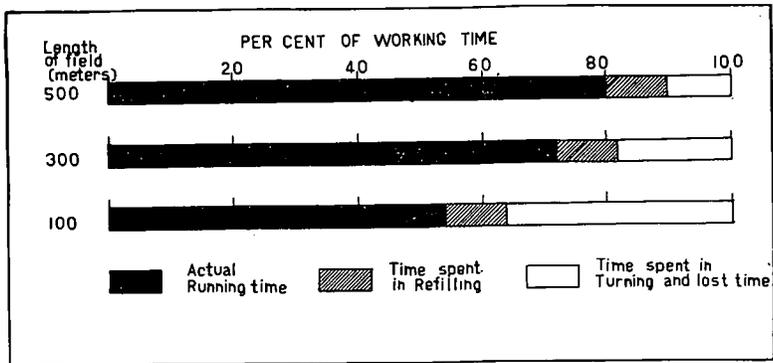


FIGURE 1. PERCENTAGE DISTRIBUTION OF WORKING TIME IN DRILLING GRAIN IN FIELDS OF DIFFERENT LENGTHS

The capacity of the grain drill was .75 kilograms

Dr. Buchholz of my own institute at Göttingen has made a study of the labor methods used in cutting asparagus in one of the most important asparagus producing areas of northern Germany. The asparagus is all cut by hand. A study was first made of the types of knives used; the material of which they were made, and their shape, length, and weight. None of the knives in use were found to be entirely satisfactory; about 25 per cent were classified as good, 50 per cent as fair, and the remainder as poor. It was found that there were considerable differences in the way in which different people perform the operation of cutting asparagus. Time and motion studies were made of each method. The number of motions made with each hand in performing the operation were counted (table 2).

You will find the same wide variations if you investigate almost any kind of farm labor operation. A variation in the rela-

tive time required to perform a given task of from 100 to 226, such as is shown in table 2, is very great. Use of inefficient methods means loss of time and loss of money.

I have read with interest during the past year of the corn-husk-

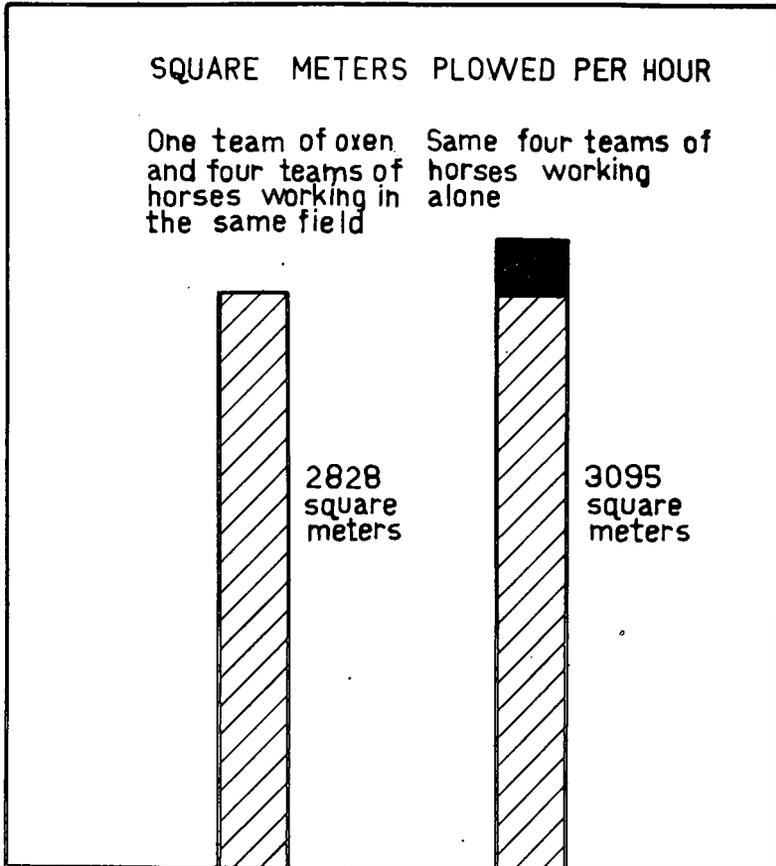


FIGURE 2. NUMBER OF SQUARE METERS PLOWED PER HOUR BY ONE TEAM OF OXEN AND FOUR TEAMS OF HORSES WORKING TOGETHER IN THE SAME FIELD, AND BY THE SAME FOUR TEAMS OF HORSES WORKING ALONE
The oxen and horses working together travelled at the rate of 1.9 kilometers per hour, while the same horses working alone travelled at the rate of 2.6 kilometers per hour.

ing contests held in the United States. To make such contests of the greatest possible use, time and motion studies should be made at the time such contests are held.

One of the principal objects of a science of agricultural labor

is to find ways and means of keeping the agricultural population healthy, through reducing to a minimum undue fatigue. A beginning has been made in studying fatigue at Pommritz and at Göttingen, where the methods developed in the field of human physiology have been employed. Through the use of a respiration apparatus it is possible to measure the amount of energy used in performing a given piece of work. An experiment was carried out under laboratory conditions at Göttingen to determine the amount of energy required to perform the motions incident to picking up potatoes in each of three different ways. Small wooden balls of about the same size and weight as potatoes were

Table 2. Number of Motions Made in Cutting Asparagus by Different Methods

Method	Number of motions			Relative amount of time required
	Left hand	Right hand	Total	
I.....	8	1	9	161
II.....	5	7	12	193
III.....	4	4	8	100
IV.....	3	8	11	226
V.....	7	6	13	194

used in the experiment. The person performing the work picked up the balls while in each of three different positions (figure 3). The apparatus used for supporting the body shown in the figure is a machine invented in Denmark which is used to some extent in thinning beets. The amount of energy required to perform the work in each of the three different positions shown in the illustrations, is given in table 3. In thinning beets the relatives were as follows: While bending over, 100, while kneeling, 94.5, while supported in the machine, 80.9.

Experiments have been carried on at Pommritz to determine the effect of the weight of the individual grain bundle upon the amount of energy required to load a wagon of bundled grain. A bundle weighing 7.5 kilograms was found to be the best size. More energy was required to load the wagon when either smaller or larger bundles were used. Many other experiments have been carried out along somewhat similar lines.

The human labor requirements of agriculture have, of course,

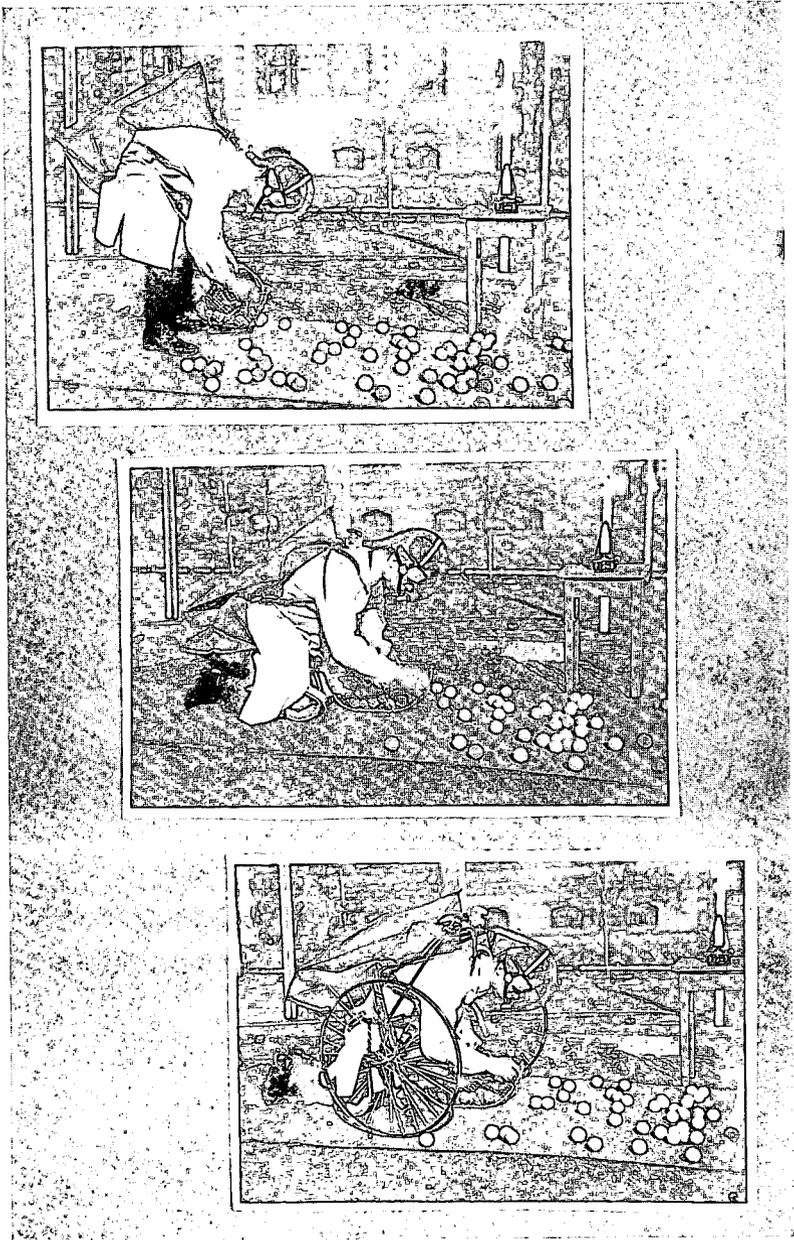


FIGURE 3. MEASURING THE AMOUNT OF ENERGY REQUIRED TO PERFORM A GIVEN PIECE OF WORK WHILE IN DIFFERENT POSITIONS, BY MEANS OF A RESPIRATION APPARATUS

The number of calories of energy used in performing the work in each of the three positions is given in table 3.

been greatly reduced through the introduction of farm machinery. At the same time it must be kept in mind that machines are not well adapted to certain types of work, and that in any case the machines must be operated by human labor. Machines should be designed not only to efficiently perform an actual mechanical operation, but in addition they should be so constructed as to reduce to a minimum the amount of human energy required to operate the machine. This latter consideration has frequently been overlooked by our engineers in Germany.

Farm lay-out and size of farm have an important bearing upon labor requirements. There is a great deal of difference in the lay-out of the typical German and of the typical American farm.

Table 3. Amount of Energy Required to Perform the Work of Picking Up Potatoes in Each of Three Different Positions*

Position of worker (figure 3)	Calories of energy used in 5 minutes	Relative
Bent over	19.2	100
Kneeling	15.7	81.8
Supported in machine	11.1	57.7

* Based on laboratory experiments carried on at the University of Göttingen.

In Germany the majority of farmers live in villages rather than on the farm. Some of the fields are located at very considerable distances from the buildings, and the fields are frequently small and irregular in shape. Under such conditions it is impossible to make efficient use of labor. In the United States on the other hand the farmer lives on his farm and can so locate his buildings as to reduce travel to and from the field to a minimum. He can in most cases arrange his fields as to size and shape so as to permit of the efficient use of machinery. I must say, however, that in driving through the country I have seen many irregular shaped fields which were not of the best size for efficient operation.

It is sometimes possible to improve the shape of a field through exchanging land with an adjoining farmer. A map of each of two fields in Pommritz before and after such an exchange is shown in figure 4. The saving in the time required to plow, cultivate, harrow, drill, and hoe the fields following the exchange of the land is given in table 4.

The importance of the shape of a field varies inversely as its

size. Small irregular shaped fields do not permit of the efficient use of labor. The economies effected through the consolidation of small irregular fields into larger fields of a somewhat better shape are illustrated in figure 5.

The location and construction of the farm buildings is another factor which has an important bearing upon labor requirements. The type of farm buildings used in Germany differs somewhat in different parts of the country. In most cases, however, the cattle

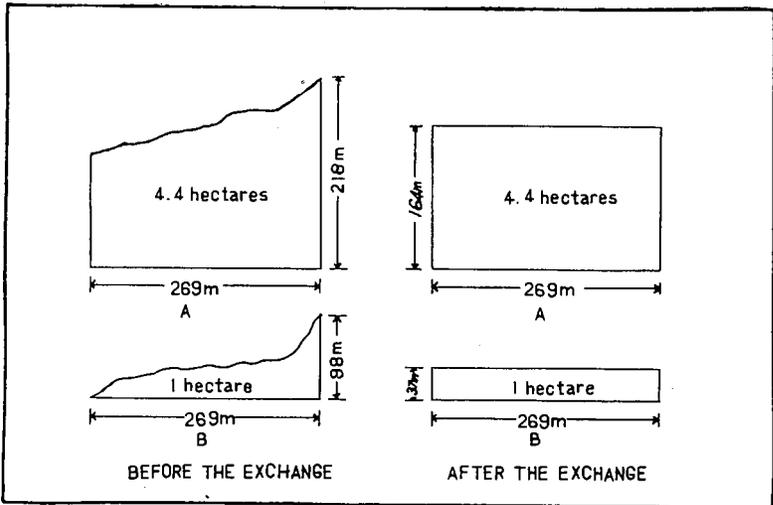


FIGURE 4. CHANGES MADE IN THE SHAPE OF FIELDS BY EXCHANGING LAND WITH ADJOINING PROPERTY OWNERS, POMMRITZ, GERMANY

Small, irregularly-shaped fields do not permit of the efficient use of labor. Generally speaking, fields which are rectangular in shape can be most efficiently worked (table 4).

and horses are housed under the same roof as the farmer and his family. One end or one side of the building is used as the house, and the remaining end or side is used as a cattle and horse barn, and has a storage for grain and hay. Two typical buildings of this type of construction are shown in figures 6 and 7. Such an arrangement greatly reduces the time required for going back and forth between the house and barn. Many buildings of this type are not, however, conveniently arranged, which results in the loss of much time and labor. Frequently a rearrangement could easily be made which would greatly reduce the

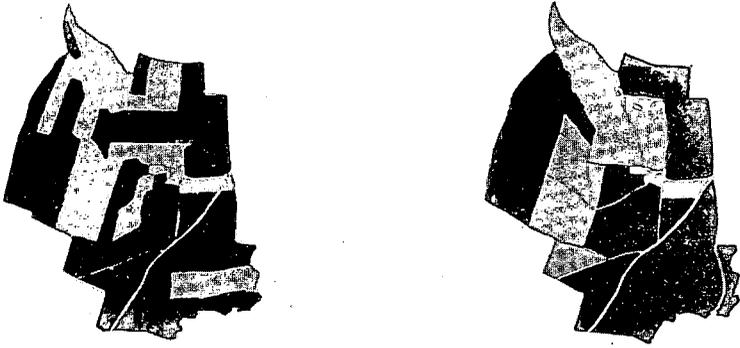


FIGURE 5. ECONOMIES IN THE USE OF HORSE AND MAN LABOR CAN SOMETIMES BE EFFECTED THROUGH CONSOLIDATING SMALL, IRREGULARLY-SHAPED FIELDS INTO LARGER FIELDS OF A BETTER SHAPE

Before the small fields were consolidated, three men, three women, and three horses were required to work this farm. After consolidation only two men, two women, and two horses were required to do the work.

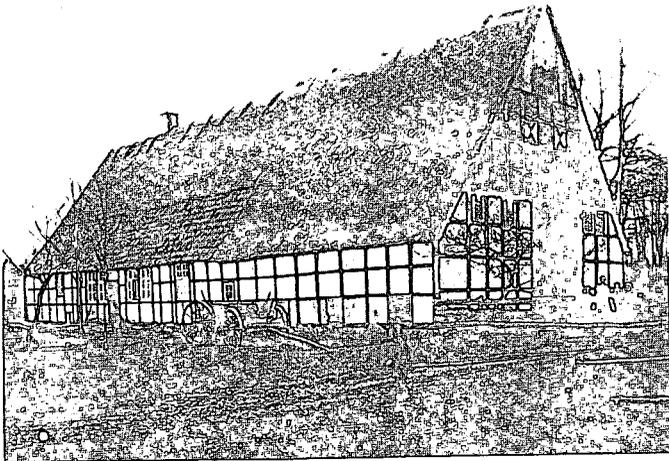


FIGURE 6. A FARM DWELLING IN HANOVER

The farmer and his family live in the end of the building shown in the background. The horses and cattle are stabled on the ground floor in the forepart of the building, while the second story of this part of the building is used as a storage for grain and hay.

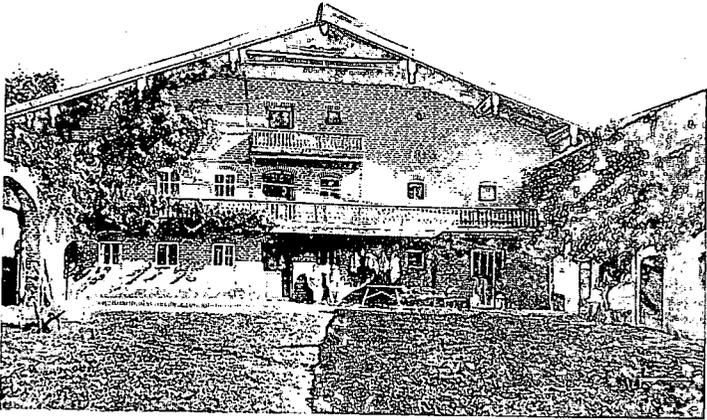


FIGURE 7. A BAVARIAN DWELLING

The farmer and his family live in the side of the building shown at the left. The horses and cattle are stabled on the ground floor in the side of the building shown at the right, while the second story of this part of the building is used as a storage for grain and hay.

labor requirements. This applies not only to the barns but to the houses as well.

I have found many well-designed barns in the United States. However, the lay-out of the farmstead is frequently very poor. Apparently no system was followed in the arrangement of farm buildings relative to one another. In many cases the house was at a very considerable distance from the other buildings. It would seem that the danger of fire has been somewhat exaggerated. The loss of time and labor resulting from poor building arrangement

Table 4. Percentage Saving in the Time Required to Perform Certain Field Operations Resulting from an Improvement in the Shape of the Field Through Exchanging Land with Adjoining Property Owners*

Field Operation	Saving in time	
	Field A (4.4 hectares)	Field B (1 hectare)
	(Percent)	(Percent)
Plowing.....	5	24
Cultivating.....	4	39
Harrowing.....	9	38
Drilling.....	9	40
Hoing.....	8	38

* See figure 4 for shape of fields before and after the exchange of land.

is usually a more important expense item than the cost of fire insurance.

Labor saving devices such as elevators for hay, grain, and straw, are to be found in many farm buildings in Germany, although they are still not as common as we would like to see them.

When we first started our investigations, our work was not received with much enthusiasm by the farmers. The majority of them were of the opinion that no one knew more about organizing farm work than did an experienced farmer. This, of course, was the same attitude taken years ago toward scientific work in the fields of plant industry and animal nutrition. After awhile, however, when we had secured some results, they began to see that the problems which we were attempting to solve were nothing more than the problems confronting every good farmer in the planning of his work. Farmers operating the larger farms first became interested. They employed a large amount of hired labor

and had tried to make use of systems of wage payment worked out under the Taylor system. Agricultural labor in Germany is for the most part paid on a time basis, although before the war a considerable amount of piece work was done. After the war, due largely to the activities of the labor unions, the piece work system of payment was abandoned. After completing certain of our investigations, we recommended a bonus system of wage payment, known as Penumpraemienlohn. Under this system the worker gets a certain daily wage, and upon the completion of a given task, he receives a premium or bonus. This system has worked out very well in those cases where sufficient care has been taken in working out the details of the scheme. A careful analysis must be made of each job to be performed. It is impossible to make general recommendations because conditions change not only from farm to farm but also from field to field, and sometimes from day to day, or even from hour to hour. In some instances the farmer would not make the necessary time studies, but attempted to arrive at a satisfactory basis of wage payment by setting up rough standards based upon our findings. In the majority of such cases the farmers lost money or the laborers were dissatisfied. As is usually the case in such instances, the farmer blamed the system rather than himself.

In recent years piece work has again been introduced to a certain extent. Our studies show that the use of piece work and bonus systems of wage payment have increased the efficiency per worker from 30 to 50 per cent.

We have learned that a willingness to work on the part of the laborer is equally as important a consideration as is his physical ability to work. One of our greatest tasks is to devise ways and means of keeping our laborers contented and willing to work as efficiently as possible. The small, independent operator, who has as a motive his own self interest is generally considered to be the most industrious and efficient of agricultural workers. However, there are, of course, wide differences between individuals even within this group. It should be our object to keep an able and industrious class of people on our farms. We have already lost many of our best people to the cities.

It is, of course, impossible to make as efficient use of labor in agriculture as in industry. However, there is a great deal of agricultural labor in Germany which is not efficiently used due

to the fact that the farm business is poorly organized. By a careful selection of crop and livestock enterprises and by the use of a carefully planned crop rotation, many economies in the use of labor can be effected. Each day offers many opportunities either to save labor or to waste it. If books are kept, and if each day's work is carefully planned in advance, many mistakes will be avoided. Many German farmers are making much more efficient use of their labor through the use of such methods.

It is difficult for the individual farmer to make the careful investigations necessary in order to work out the most efficient methods of performing various farm operations under his particular conditions. In order to overcome this difficulty, the German Agricultural Society (Deutsche Landwirtschafts Gesellschaft) created some ten years ago a special division to make studies of this kind. Specially trained college graduates were furnished the small local associations of farmers, known as Landarbeitsringe, to make the necessary labor studies. Some of the results of their work have been published.² The method of organizing these "rings" and the methods used in working out various problems will shortly be published by the Institute of Agricultural Economics at the University of Göttingen, Göttingen, Germany.

We have but made a beginning in this work. A certain number of other countries have already followed our example in making studies of this sort. The problem of how to use the labor employed in agriculture most efficiently is an international one. There are very few countries which do not have something to learn from the experiences of other countries. It would be of great scientific value if studies were made in every country in the world of the methods employed by the most efficient farmers in the use of labor, and if careful scientific descriptions were available of the methods used in performing each of the various farm operations.

Our scientific research is only a means to an end, namely, to educate our rural population in the best methods of carrying on their work. In Germany a great deal of work has been done in training our people in schools and colleges. During the past month I have seen in the United States some of the finest of agricultural colleges. However, up to the present time very little work

² See bibliography, pages 964-966.

has apparently been done in the training of agricultural labor. Most of our agricultural colleges in Germany have taken up work along this line during the past few years. Many courses for extension workers, farmers, and farm laborers have been given at the experimental farms at Pommritz and Bornim. Recently some of the larger farms have given short training courses for their apprentices. There are a number of schools which have been established for sometime, for training workers for the dairying and hog raising industries. Our numerous agricultural schools have also begun to give instruction along these lines.

As labor is not so plentiful in the United States as in Germany or in other European countries, I am convinced that there is a large field for scientific investigations of the kind which we have been carrying on. There is no question but that the results would pay for the effort and money put into the work.

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