TRACTORS AND HARVESTER THRESHERS IN SELECTED COUNTRIES THE SECOND HALF OF THE XX CENTURY

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INTRODUCTION

Among the various countries and regions of the world the number of machines used in agriculture is vastly different. For example in Sub-Saharan Africa there are only 0.12 tractors per 100 hectares of agriculturally used area (AUA) while in Japan there are 50 tractors per 100 hectares of AUA [2]. Even among the industrialized countries the history of the development of farm mechanization has been quite different. By 1950 a high level of mechanization was observed in USA, while in Western Europe (except the UK) and in Japan farming was still done with animal power. A dynamic growth in the number of tractors and farm implements occurred in Western Europe during the 1950s and 1960s, and the 1960s and 1970s for Japan. The changes (both in time and regional aspects) on the farm mechanization were the result of a number of factors. There is a strong interdependence between the equipment in farm machinery and the implementation of emerging agricultural engineering practices. This is very important because agricultural engineering is now "addressing great challenges facing humanity, such as ensuring adequate and safe food supply for an expanding world population and managing and protecting the world's vital water, soil, air and energy resources" [3].

The purpose of this paper is to describe the main trends occurring in the equipment of agriculture in farm machines during the second half of the XX century, and discuss the possible reasons for the changes. Tractors and harvester threshers, as the most representative agricultural machinery, were used for this study. Statistical data from 4 countries (France, Germany, Poland and the USA) was assembled and analyzed. Therefore, there is a need to adjust the farm mechanization to the new exigencies of economic, social and ecological nature.

MATERIALS AND METHODS

Data from statistical yearbooks of the particular countries, from international organizations, professional magazines like Implement & Tractors, and information by courtesy of organizations such as AEM, UNACOMA, and VDMA was used as information sources for this paper. The gathering of yearly information for the time period between 1950-2000 proved to be a difficult task. The information was limited as to the long-period analysis of trends in the farm machinery statistics.

In many cases there are significant differences in the data from similar sources. One example is the number of tractors in use in the USA published by the Yearbook of Agricultural Statistics (edited by USDA) and the FAO Production Yearbook. For this and similar situations, data from national statistical yearbooks (if available) were treated as valid. Another problem was the decreasing amount of data relating to farm mechanization presented in the statistical yearbooks.

The analysis of the farm machinery was carried out using the background of processes observed in other aspects of agricultural reality, such as structural changes, price relations, technological advances and so on.

RESULTS AND DISCUSSION

The situation of the farm machinery, as seen from both a qualitative and a quantitative point of view, is strictly linked with a stage of development of agricultural mechanization. At the beginning the number of machines in use grew slowly as expressed in absolute values, but very fast in relative (%) values, because of the very low starting point. In the next stage, the rate of absolute values of increase in the number of machines in use became more and more dynamic along with a gradual decrease of the relative growth. After an achievement of relative saturation, which by no means meant that all the farms were equipped with a machine, the numbers of machines in use tended to decrease.

Qualitative changes were also observed. That was because of changes in farms size structure, scale of agricultural production and the level of specialization. Decrease in the number of farms and specialization of production caused the number of potential users to drop. At the beginning of this stage the number of machines in use was still growing. However, later on the decreasing trend was observed. The changes in number of farms were related to the growth of their average size (Table 1). In Table 1, the number and average size of farms in Germany refers only to the western part of the country. After the unification the average size of a farm has become larger. In 2000 it averaged 37 hectares of AUA for the whole country, and the total number of farms amounted to 450 thousand units.

Table 1. The number and average acreage of farms in selected countries

Countries		1950	1955	1960	1965	1970	1975	1980	1985	1990	2000
France	A	2065	1990	1774	1688	1421	1209	1135	1022	928	735[1]
	B	15	16	17	19	21	24	26	29	31	39[1]
Germany[2]	A	1647	1550	1385	1206	1083	905	797	721	630	420
	B	8	8	9	11	12	14	15	17	19	27
Poland	A	2985	2895	3254	3145	3236	3068	2396	2291	2143	1892
	B	7	7	6	6	6	6	7	8	8	9
USA	A	5388	4782	3720	3158	2954	2808	2309	2240	2146	2000
	B	86	97	127	136	149	155	171	180	187	195

A – number of farms in thousands, B – average size of farm in hectares, [1] 1995, [2] without former GDR
Source: Statistical yearbooks of particular countries

In the United States the first of the above-mentioned stages of development of agricultural mechanization was already over by 1950, in France and Germany – at the beginning of the fifties, whilst in Poland – at the end of the sixties. The Second World War in Europe hampered the development of agriculture and caused regress even in the highly industrialized countries of Western Europe, compared to the USA, in the stages of the development of farm mechanization. That was especially true during the early post-war period. Another factor causing the differences was the farm structure. Smaller farms in Europe were more difficult to mechanize than the much larger ones in the USA. Therefore, only in the 1950s and 1960s the number of tractors and harvester threshers grew dynamically in the Federal Republic of Germany (FRG) and in France (in 1950 there were 143 000 tractors in France increasing to 1 265 000 in 1970). At the same time in the USA a decreasing tendency was observed while in Poland the small number of tractors available were assigned to state farms and to machinery stations serving co-operative farms. In Poland, however, there was some increase in the number of tractors in use. The shipments were addressed to state and co-operative farms, and since 1959 also to agricultural circles, which were farmers' organizations aiming at the mechanization of private farms in the form of machinery services. Poland was the only country in Central and East European socialist block, where private sector agriculture dominated. However, for doctrinal reasons, private farmers were not permitted to buy tractors. That is why, in spite of an increase in the number of tractors in agricultural circles, animal power dominated on private farms with a 70% share in total power resources in 1970. Besides, the tractors of the agricultural circles were only in 20-30% engaged in services for farmers. The dominant work assignment for the tractors was as transport services for state industrial enterprises.

In Poland, the decrease in number of horses started only during the seventies, when private farmers were allowed to buy tractors (at the beginning second-hand ones, from state farms and agricultural circles, then also newly-produced ones). At that time the prices of farm machines as well as of other goods were centrally imposed by the government. The price relations between farm machines and agricultural products were, generally, favorable for farmers.

In West European countries the changes in the farm size structure and a relative saturation of farms with tractors were the main reasons for a drop in the

number of tractors in use and then also for the appearance of the declining trend in France and FRG. In the USA saturation had been reached even earlier. The decreasing trend in the American agriculture appeared already during the fifties.

The need to overcome the economic constraints forced the farmers to look for a more efficient use of production factors. One of the solutions was specialization, which meant limiting the number of types of crops and animals on the farm. In plant production this made it possible to enlarge the size of fields and scale of production of chosen crops and at the same time to limit the number of types of machines needed and increase the annual use of the rest of the machines. From the point of view of farm mechanization this was a good solution, ensuring reduction of investment inputs as well as the operating costs of farm machines thanks to a higher annual use and higher working capacities achieved on larger fields. Progress in the specialization of agricultural production was another reason for the decrease in the number of potential users of farm machines. On the other hand, on larger and more specialized farms the equipment of higher capacity was needed. In the USA, between 1950 and 1990 the average power of tractors in use increased by 147% from 21.4 kW to 52.8 kW. Also in Western Europe a growth of average power of tractors was observed. Using the FRG as an example, this growth within the period of 1950-1990 amounted there to 86%.

Another reason of the decreasing trend in a number of tractors in use were changes in the relative price between farm machines and agricultural products, which were unfavorable from farmers' point of view. A continuous growth of farm machinery operating costs forced farmers to look for more efficient ways of utilization. One solution was multi-farm use of farm machines. These forms differed in various countries. In the USA, where large-scale farming was prevalent, the contractor system was typical, whereas in FRG, with its smaller farms, the system of exchange of services between farmers (within the machinery circles) dominated, though the contractor system was also present. In France a special form of machinery co-operatives (CUMA) was the most popular form of multi-farm use of machines. Implementation of the multi-farm machinery use system results in lower needs as to the number of machines and the necessity of higher working capacities. As a result of changes in structural, technological, economic and organizational factors, the number of tractors in use for agriculture in industrialized countries has tended to decrease. In the USA the decrease in the number of tractors in use started around 1968, in France – from the beginning of eighties, in FRG after 1986. However, in none of these countries has the above-mentioned decrease resulted in a lower level of agricultural mechanization. In fact, replacing the older tractors with a smaller number of modern ones has ensured greater working capacities, better quality of work, comfort and reliability. Besides, the number of tractors per 100 farms has still been growing (Table 2). A different trend in Germany during 1990's was caused by the unification with former GDR having quite a different farm structure and equipment in tractors.

Table 2. Tractors in selected countries

Countries		1950	1955	1960	1965	1970	1975	1980	1985	1990	1995	2000
France	A	0.43	1.01	2.22	3.12	3.84	4.22	4.58	4.74	4.71	4.36	4.21
	B	0.67	1.59	3.59	5.16	6.62	7.19	7.84	7.88	7.50	6.73	6.44
	C	6.90	17.00	43.30	62.80	89.00	112.7	128.7	145.9	155.2	178.5	189.0
Germany[2]	A	0.99	3.21	6.02	8.39	10.10	10.71	11.98	12.34	9.15	7.07	6.26
	B	1.75	5.65	10.63	15.02	17.97	18.82	19.58	19.90	12.64	9.96	8.85
	C	8.5	29.70	61.80	96.50	126.6	157.4	184.1	205.7	248.8	214.4	226.8
Poland	A	0.14	0.24	0.30	0.63	1.24	2.09	3.27	4.90	6.33	6.96	7.10
	B	0.17	0.30	0.38	0.80	1.58	2.64	4.13	6.25	8.08	8.89	9.12
	C	1.00	1.7	1.90	3.90	7.50	13.1	25.90	40.40	55.3	63.40	69.10
USA	A	0.59	1.01	1.06	1.09	1.10	1.10	1.07	1.04	1.03	1.02	1.03
	B	2.25	2.97	2.54	2.69	2.70	2.49	2.41	2.36	2.33	2.28	2.40
	C	68.30	93.70	126.2	152.0	161.5	166.8	199.1	200.0	204.3	207.1	211.5

A – pcs per 100 hectares of AUA, B – pcs per 100 hectares of arable land, C – pcs per 100 farms[1] 1995,
[2] without former GDR
Source: Statistical yearbooks of particular countries

The number of harvester threshers in use was growing in USA until the end of the fifties, in France until 1975 and in FRG until 1976. Only in Poland the number of harvester threshers in use grew until the end of the century. The growth in the number of harvester threshers in Poland during nineties was achieved mostly because of many purchases of imported second-hand machines and the prolonging of their useful life.

After the period of growth, the number of harvester threshers per 100 hectares of agriculturally used area and per 100 hectares of cereals has now, in general, a decreasing tendency (Table 3). However, the number of harvester threshers per 100 farms is still growing, except the USA, where the value of the index since 1960 has not changed much.

Table 3. Harvester threshers in selected countries

Countries		1950	1955	1960	1965	1970	1975	1980	1985	1990	1995	2000
France	A	0.02	0.05	0.17	0.32	0.40	0.47	0.45	0.42	0.41	0.39	0.36
	B	0.08	0.17	0.64	1.17	1.41	1.58	1.45	1.35	1.34	1.40	1.15
	C	0.30	0.80	3.30	6.40	9.40	12.70	12.5	12.8	13.40	15.80	16.00
Germany[2]	A	0.00	0.06	0.23	0.87	1.23	1.34	1.36	1.27	0.90	0.82	0.78
	B	0.02	0.18	0.66	2.41	3.22	3.36	3.20	3.13	2.26	2.20	1.87
	C	0.0	0.60	2.30	10.00	15.50	19.70	21.00	21.20	24.60	24.90	28.20
Poland	A	0.00	0.00	0.02	0.03	0.07	0.11	0.21	0.30	0.44	0.52	0.53
	B	0.00	0.01	0.03	0.06	0.16	0.27	0.50	0.68	0.95	1.130	1.10
	C	0.00	0.00	0.1	0.20	0.40	0.70	1.60	2.50	3.80	4.70	5.10
USA	A	0.11	0.22	0.24	0.21	0.18	0.16	0.15	0.15	0.14	0.13	0.13
	B	0.96	1.43	1.91	1.50	1.30	0.93	0.91	0.96	0.96	0.93	0.91
	C	13.2	20.50	28.0	28.80	26.70	23.7	28.2	28.60	28.50	26.8	26.3

A – pcs per 100 hectares of AUA, B – pcs per 100 hectares of cereals, C – pcs per 100 farms [1] 1995, [2] data for 1950-1985 without former GDR
Source: Statistical yearbooks of particular countries

Along with the quantitative changes in farm mechanization there were significant qualitative developments during the second half of the XXth century. The power of engines of tractors and self-propelled machines grew dynamically.

The working widths of machines showed a similar trend. Nowadays, the harvester threshers with headers of 9 m are not an exception in industrialized countries. There were also great changes in the structure of farm machinery park. The share of trained harvester threshers in the structure decreased in favor of the self-propelled ones. An enormous progress has been observed in the field of electronic equipment. The use of on-board computers and other electronic facilities enables better control of working processes and makes it possible to implement the precision agriculture systems. All this makes the working capacities and, consequently, the labor productivity increase. But along with the use of larger and larger machines the consumption of energy grows dramatically, what is strictly connected with negative effects on the environment. Agricultural production of all the developed countries is dependent on nonrenewable fossil energy, the majority of which is converted into the ecosystem and causes soil destruction. It is also dependent on the accessibility of information [1]. The future agriculture production system has to be created, taking into consideration the necessity to find a proper balance between information sources, energy inputs and environment control.

SUMMARY AND CONCLUSIONS

The main factors affecting the equipment in farm machines are: 1) the number of potential users (farms), 2) level of specialization of agricultural production, 3) price relation between farm machines, agricultural products and the economic situation of farmers, etc.

Reduction in the number of farms together with advances in specialization and concentration of production has caused a decrease in the number of machines in use and the growth of working capacity, technological standards, requirements toward quality and comfort of work, reliability, safety and environmental protection.

The future development of the farm mechanization in Poland will depend on the evolution of the agricultural situation and of the entire national economy. The present demand for farm machines is limited by the purchasing power of farmers and currently does not even ensure the simple replacement of existing machines. Even though in Poland a decrease in the number of machines in use did not occur until the end 1990s, the machinery resources are growing older and, at least in part, technologically obsolete.

Improvements in the structure of farming in Poland could improve the current situation. For this to happen the creation of new jobs out of agriculture is necessary.

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SUMMARY

In the 1950s and 1960s the number of tractors and harvester threshers grew dramatically in the Federal Republic of Germany (FRG) and in France (in 1950 there were 143000 tractors in France increasing to 1265000 in 1970). At the same time the number of above-mentioned machines in use in Poland was still low, but with an increasing trend. In the USA a decrease was already occurring in 1960s, while in France and in the FRG only in 1970s (harvester threshers) and 1980s (tractors). The reasons for the decrease were: 1) a reduction in the number of farms and the increased use of specialization, 2) changes in technology and the way farm machinery was utilized, 3) an increase in the cost of production versus the value of the agricultural products. In Poland the decrease in the number of machines in use did not occur until the end 1990s, due to a lower stage of development of the farm mechanization and the prolonging of a useful life of the existing machines.