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Repair and Maintenance Costs – Results from a Survey

As repair and maintenance costs account for a substantial proportion of total machine costs, up-to-date information on their amount is very important to farm management. Therefore, a written survey of farms in Lower Saxony and Baden-Württemberg in 2010 was conducted. It showed that in some cases the costs of repairs, service and maintenance on agricultural machinery are far removed from those used in the KT BL basis of calculation, with the KT BL-data excluding maintenance. The greatest differences occurred with –56 % in the case of tractors and with +548 % for trailers. The figures for telehandlers and harrows displayed with –12 % and respectively +6 % the greatest similarity.

Keywords
Machinery costs, repair costs, maintenance, agricultural machinery, Germany

Abstract
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When it comes to managing an agricultural business it is essential to have access to reliable data on how much your machines are costing you. A not inconsiderable proportion of the costs incurred relates to repair work and the maintenance of the machinery. Depending on the type of machine, this may represent between 15% and 45 % of the overall machine costs. In order to obtain an overview of the situation in the field, the KTBL, together with the Research Institute Agroscope Reckenholz-Tänikon ART (Switzerland) conducted a written survey among farm managers in Lower Saxony and Baden-Württemberg [1]. The aim of this survey was:

- to acquire some knowledge of the level of repair and maintenance costs of selected agricultural motor vehicles and machinery on farms,
- to compare the actual results with the calculation base in current use and
- to examine the extent to which questionnaires on farms represent an appropriate means of acquiring data that is both current and reliable.

In order to achieve a more accurate determination of the composition of costs for repairs and maintenance, three separate categories were identified:

- Repairs carried out as a consequence of damage associated with risk, e. g. damage to engines
- Service work = Periodic replacement of consumables such as engine oil and key parts subject to wear such as ploughshares
- Maintenance work = Regular work on maintaining the machine, e. g. cleaning

Material and Method

The survey of machine costs, consisting of a two-stage procedure, was conducted in the German Federal States of Lower Saxony and Baden-Württemberg in the autumn of 2010. In a preliminary survey, a questionnaire was sent to 550 farms in each of these Federal States enquiring about the numbers of particular machines. Depending on the machines in operation on the farms, the respondents to this preliminary questionnaire then received a second questionnaire compiled on an individual farm basis. The rate of return for the preliminary survey was 11.8 % in Lower Saxony and 17.1 % in Baden-Württemberg. People who responded to this preliminary questionnaire were sent a second questionnaire, compiled on an individual farm basis and geared to the existing machinery. The ensuing rate of return in relation to all 1 100 farms contacted was 4.1%. This enabled us to extract and evaluate a total of 669 data sets based on 18 different types of machines (**table 1**).

In addition to general information about the machines such as make, model, fittings and equipment, performance and working width, the focus was on the full complement of expenditure on repairs, service and maintenance work carried out in the years 2007 to 2009. For all three categories a differentiation was made as to whether the farm managers had the work carried out in an agricultural machinery workshop or undertook it themselves.

Subsequently the costs were recorded, either by using the workshop invoice or by reference to the disbursements for consumables and spares, as well as an evaluation in monetary terms of the working hours expended by the farm manager (15.- €/h).

The questionnaire also covered details such as year of construction of the machine and capacity utilisation over the three years studied. The latter enabled costs for repairs, service and maintenance works to be derived for each unit of measurement (e. g. working hours, hectares, tonnes, **table 2**).

A further evaluation was conducted covering the repairs carried out on the tractors and, in order to do this, all repairs reported were combined into eleven groups. Based on the number of repairs incurred, the probable frequency of occurrence per

Table 1

Overview of the machines evaluated

Maschinentyp *Machinery Type*	**Anzahl** *Number* **n**	**Alter** *Age* **a**	**Auslastung** *Capacity utilisation* **NE**	**Nutzungseinheit** *Unit of measurement*	**Leistung [PS], Arbeitsbreite [m]** *Power [HP], Working width [m]*	**Ausstattung (Anteile, Durchschnittswerte)** *Equipment (Percentages, Averages)*
Traktor *Tractor*	141	15	442	h	103 PS	Allradantrieb (76 %), Fronthydraulik (54 %), Klimaanlage (44 %) *all-wheel drive (76 %), front hydraulics (54 %), air conditioning (44 %)*
Teleskop-, Hof-, Radlader *Telehandler, yard loader, wheel loader*	9	9	534	h	80 PS	Maximale Hubhöhe 4,1 m, Hydrostatischer Antrieb (89 %), Allradantrieb (67 %) *maximum lifting height 4,1 m, hydrostatic drive (89 %), all-wheel drive (67 %)*
Mähdrescher *Combine*	9	11	112	h	211 PS	Arbeitsbreite *working width* 4,8 m
Grubber *Cultivator*	39	9	191	ha	3,8 m	Schwergrubber *chisel cultivator* (74 %)
Pflug *Plough*	36	13	72	ha	1,8 m	Volldrehpflug (81 %), Steinsicherung (53 %) *reversible plough (81 %), trip leg system (53 %)*
Egge *Harrow*	36	14	85	ha	3,8 m	Kreiselegge *rotary harrow* (44 %)
Sämaschine *Seeder*	31	12	83	ha	3,1 m	Mechanisch (75 %), Schleppschare (52 %) *mechanical (75 %), suffolk coulters (52 %)*
Einzelkornsämaschine *Precision seed drill*	16	18	37	ha	5 Säaggregate *seeder units*	Pneumatisch (56 %), Mais (71 %) *pneumatic (56 %), maize (71 %)*
Pflanzenschutzspritze *Pesticide sprayer*	37	14	408	ha	1 650 l Fassungsvermögen/*capacity*	Arbeitsbreite 17 m, Dreipunktanbau (68 %) *working width 17 m, three-point linkage (68 %)*
Stallmiststreuer *Manure spreader*	6	24	222	t	5,3 m³ Fassungsvermögen/*capacity*	Einachser (100 %), Kratzbodenantrieb mechanisch (100 %) *single-axle (100 %), mechanical scraper floor transmission (100 %)*
Mineraldüngerstreuer *Mineral fertiliser spreader*	33	11	81	t	1 432 l Fassungsvermögen/*capacity*	Arbeitsbreite 18 m, Dreipunktanbau (97 %), Streuscheiben (97 %) *working width 18 m, three-point linkage (97 %), diffusers (97 %)*
Güllefass *Slurry tanker*	30	15	3 189	m³	9 883 l Fassungsvermögen/*capacity*	Arbeitsbreite 14 m, Vakuumpumpe (64 %), Breitverteiler (73 %), Tandemachse (67 %) *working width 14 m, vacuum pump (64 %), spreader (73 %), tandem axle (67 %)*
Kreiselmäher *Rotary mower*	38	9	69	ha	2,7 m	Dreipunktanbau (100 %), Trommelmähwerk (58 %), Heckanbau (56 %) *three-point linkage (100 %), drum mower (58 %), rear mounting (56 %)*
Kreiselheuer *Rotary tedder*	24	13	118	ha	6,4 m	Dreipunktanbau(100 %), hydraulisch klappbar (59 %) *three-point linkage (100 %), hydraulic folding (59 %)*
Kreiselschwader *Rotary windrower*	24	11	94	ha	5,1 m	Dreipunktanbau (83 %), hydraulisch klappbar (29 %) *three-point linkage (83 %), hydraulic folding (29 %)*
Ladewagen (Häckselguttransportwagen) *Forage wagon (silage trailer)*	19	16	4 186	t	34 m³ Fassungsvermögen/*capacity*	Pick-Up (89 %), Dosierentladung (53 %) *pick-up (89 %), discharge dosing (53 %)*
Rundballen-, Quaderballenpresse *Round, square baler*	7	24	2 279	Ballen/bales	kA	Hochdruckballenpresse (71 %), Rundballenpresse (29 %) *high pressure baler (71 %), round baler (29 %)*
Anhänger (Kipper) *Trailer (tipper)*	134	22	383	t	8 t Nutzlast/*payload*	maximale Geschwindigkeit 31 km/h, kippbar (95 %), Zweiachser (93 %) *maximum speed 31 km/h, tipper (95 %), two-axle (93 %)*

h = Stunde/*hour*, ha = Hektar/*hectare*, t = Tonne/*tonnes*, m = Meter/*metre*, kA = keine Angabe/*not stated* , PS/HP = Pferdestärke/*horse Power*, km = Kilometer/*kilometre*

Table 2

Costs per unit of measurement for Repairs, Service and Maintenance

Maschinentyp *Machinery Type*	Nutzungseinheit *Unit of measurement*	Umfrage Niedersachsen und Baden-Württemberg *Survey in Lower Saxony and Baden-Württemberg*					KTBL 2008/09 Var. Kosten (Reparaturen) *Var. costs (Repairs)*	Differenz Umfrage zu KTBL *Difference survey v. KTBL*
		Wartung *Maintenance*	Reparatur *Repair*	Service *Service*	Wartung *Maintenance*	Total *Total*		
	NE	Akmin/*NE*	EUR/*NE*	EUR/*NE*	EUR/*NE*	EUR/*NE*	EUR/*NE*	%
Traktor/*Tractor*	h	2,2	0,98	1,20	1,05	3,22	7,40	-56
Teleskop-, Hof-, Radlader *Telehandler, yard loader, wheel loader*	h	2,3	1,85	0,46	1,32	3,63	4,12	-12
Mähdrescher/*combine*	h	16,8	2,87	4,26	5,60	12,74	15,5	-18
Grubber/*cultivator*	ha	2,6	0,10	1,73	1,07	2,90	5,50	-47
Pflug/*plough*	ha	6,2	0,24	3,04	2,28	5,56	12,00	-54
Egge/*harrow*	ha	7,9	0,06	2,94	2,78	5,77	5,43	+6
Sämaschine/*seeder*	ha	3,5	0,05	0,71	1,31	2,07	2,50	-17
Einzelkornsämaschine *Precision seed drill*	ha	10,9	0,21	0,28	4,41	4,90	8,00	-39
Pflanzenschutzspritze *Pesticide sprayer*	ha	2,0	0,32	0,20	0,76	1,29	0,95	+35
Stallmiststreuer *Manure spreader*	t	2,2	0,05	0,45	0,99	1,48	0,40	+270
Mineraldüngerstreuer *Mineral fertiliser spreader*	t	5,9	0,07	0,02	1,86	1,95	1,50	+30
Güllefass/*slurry tanker*	m³	0,4	0,34	0,05	0,15	0,54	0,40	+34
Kreiselmäher/*rotary mower*	ha	4,0	0,70	1,85	1,89	4,45	1,70	+161
Kreiselheuer/*rotary tedder*	ha	3,2	0,34	0,90	1,09	2,33	1,65	+41
Kreiselschwader/*rotary windrower*	ha	4,2	0,58	0,83	1,59	3,01	2,15	+40
Ladewagen (Häckselguttransportwagen) *Forage wagon (silage trailer)*	t	0,6	0,03	0,13	0,26	0,42	0,26	+60
Rundballen-, Quaderballenpresse *Round, square baler*	Ballen/bales	0,7	0,10	0,14	0,28	0,52	0,20	+161
Anhänger (Kipper) *Trailer (tipper)*	t	1,6	0,23	0,38	0,69	1,30	0,20	+548

h = Stunde/*hour*, ha = Hektare/*hectare*, t = Tonne/*tonnes*, m = Meter/*metre*, AKmin = Arbeitskraftminuten/*manpower per minutes*, NE = Nutzungseinheit/*unit of measurement*, EUR = Euro/*euro*, var. = variable/*variable*, v. = versus

year was derived by dividing by the number of years in use. The number of years in use is the product of the number of machines and the observation period of three years. On this basis, it was possible to calculate the expected value for the annual costs of a specific repair.

Adjustment of Machine Capacity Utilisation

On some questionnaires, an analysis of annual capacity utilisation suggested that, rather than the actual acreage capacity of the machine, it was the area (LF) used for agricultural purposes that was in fact being stated. Consequently, on machines that are capable of working an acreage several times a year or which do this in accordance with "good professional practice", the ratio of capacity utilisation to LF or to cultivated land/grassland has been calculated. By way of a criterion for adapting capacity utilisation, the limit of 1.5 transits per hectare and per year was adopted. No adaptation was necessary for machines where the level of capacity utilisation exceeded this. The average number of transits was determined based on machines with a better capacity utilisation. The figure calculated was taken as the average annual capacity utilisation for those machines that did not achieve 1.5 transits per hectare and year. This adjustment needed to be made in the case of 5 to 32 % of the pesticide sprayers, mineral fertiliser spreaders, rotary mowers, rotary tedders and rotary windrowers, with the number of transits per hectare fluctuating within a range of 2.8 to 5.2. Where field cultivators and harrows were concerned, no change to capacity utilisation was made.

Results

The results obtained from the questionnaires subsequently returned (4.1 %) do not lend themselves to generalisation due to the fact that the number of random samples was too small. At the same time, the large number of preliminary questionnaires returned (17.1 % in Baden-Württemberg and 11.8 % in Lower Saxony) indicate that the individuals questioned were basically happy to supply information. However, it is possible that the information required in the second part of the questionnaire was either not available or the expense involved in producing this data was judged to be too high.

The most important figures obtained for the machines subject of the analysis are set out in **table 1**. The largest number of data records available by far related to tractors and trailers (141/134 respectively). By contrast, the random sample conducted for telehandlers, combine harvesters, manure spreaders and balers comprised fewer than ten machines in each case. Also, the equipment/operating conditions were very different for some types of machine e. g. harrows, precision seed drills and balers. The average age of the 18 types of machine was between 9 and 24 years. Correspondingly, it was only on five types of machines (telehandlers, cultivators, the plough, the seeder and the rotary mower) that the average age was just below the expectation of technical service life as indicated by KTBL [2]. All the other 13 types of machine chalked up a mean age averaging almost six years more than their technical service life.

The repair, service and maintenance works together with expenditure on maintenance have been set out in €/NE in **table 2**, in each case in relation to the unit of measurement. The farm's own working time utilisation has been shown in labour minutes per unit of measurement (AKmin/NE). The average expenditure on maintenance for the 669 machines lay between 0.4 and 16.8 AKmin/NE. Front runners here were the combines, followed by the precision seed drills at 10.9 AKmin/NE. In addition to the slurry tankers, by far the smallest amount of working time spent on machine maintenance was on the forage wagons/silage trailers (0.6 AKmin/NE) and on the round/square balers at 0.7 AKmin/NE.

The costs for repair, service and maintenance works have been itemised in €/NE. The overall costs, which were made up of the costs for repair, service and maintenance works, added up to 3.22 €/NE for the tractors. The KTBL value for the comparable tractors (standard tractor with all wheel drive, 93–111 hp) is 7.40 € [2]. As a result the average value for all tractors in the survey was 56 % lower than the KTBL value (**table 2**).

Comparing the results of the survey with the KTBL values brought to light a picture that was anything but uniform. The statement of costs per unit of measurement for the three motor vehicles as well as the cultivator, ploughs, seeders and precision seed drills were, at 0.43 to 6.44 €, significantly below those of comparable KTBL machine data. By contrast, the costs for the other eleven machines in the survey were between 0.14 and 2.75 € higher (**table 2**).

As far as combine harvesters, seeders, precision seed drills, pesticide sprayers, manure spreaders, mineral fertiliser spreaders, rotary tedders, rotary windrowers, forage wagons, balers and trailers were concerned, it was evident that the costs for maintenance work were significantly greater than the costs for repair and service work. Machines where the components are exposed to high levels of wear and tear generated a high proportion of costs for service work. This was true in the case of cultivators, ploughs, harrows and rotary mowers. As regards the motor vehicles subject of the survey the situation that presented itself was variable. Whereas, in the case of tractors, the disbursements tended to a major extent to be for service works, when it came to the telehandlers, it was predominantly the

Tab. 3

Repairs on 141 tractors

Reparatur **Repair**	**Anzahl** ***Number*** **n**	**Kosten (Total)** ***Costs (Total)*** **EUR**	**Kosten** ***Costs* (Ø)** **EUR**	**Wahrscheinlichkeit** ***Probability p. a.*** **%**	**Erwartungswert** ***Expected Value p. a.*** **EUR**
Diverse Reparaturen *Miscellaneous repairs*	47	51.598	1.098	12,1	133
Elektrik, Steuerung-Kabelzug, Lichtmaschine, Anlasser, Relais *Electrics, cable pull control, generator, starter, relay*	18	6.047	336	4,7	16
Hydraulik, Zapfwelle *Hydraulics, PTO shaft*	16	9.984	624	4,1	26
Einspritz-, Wasserpumpe, Kühler *Injection pump, water pump, radiator*	11	10.081	916	2,8	26
Kabine, Traktorsitz, Scheiben, Tür *Cab, tractor seat, windows, door*	9	3.718	413	2,3	10
Motor/*engine*	9	22.913	2.546	2,3	59
Getriebe, Zapfwellenkupplung *Transmission, PTO coupling*	6	17.400	2.900	1,6	45
Keilriemen, Dichtung, Ventil/*v-belt, gasket, valve*	6	2.318	386	1,6	6
(Hand-)Bremsen, Achse/*(hand)brakes, axle*	4	3.735	934	1,0	10
Radlager/*wheel bearings*	3	915	305	0,8	2
Allradantrieb/*all-wheel drive*	1	1.200	1.200	0,3	3
Total/*total*	130	129.908	999	n. e.	336

EUR = Euro/*euro*, p. a. = pro anno/*per annum*, n. e. = nicht erhoben/*not recorded*

costs for repairs and, with combines, the costs associated with maintenance works (**table 2**).

The repairs carried out from 2007 to 2009 are presented in **table 3**. The 130 results obtained in relation to 141 tractors examined were summarised in eleven groups. Under the heading "Various Repairs" 47 incidents were recorded which were not described in detail by the farm managers. Engine damage on the tractors occurred on nine occasions. Dividing by 387 years' usage gives the probability of engine damage occurring. The number of years of use is derived from 141 tractors in use for 3 years (= 423) less 36 years, explained by the fact that individual tractors may not have been in use over all three years under consideration but only for one or two years. Dividing the nine instances of repair and the 387 years of use resulted in a probability of 2.3 % for one annual instance of engine damage.

The highest average costs that occurred were 2.900 € for gearbox repairs. These were considerably in excess of the costs associated with engine damage (2.546 €). The expected value p.a. – the calculated annual cost of any damaging event – was calculated by multiplying the average costs and the probability of a repair becoming necessary. The "Various Repairs" group demonstrated, at 133 €, the highest costs for engine damage with 59 € per year of use (**table 3**).

Conclusions

The results of the survey indicate that this method is of limited suitability as a means of acquiring current and reliable information from which anticipation data for the cost of repairs may be derived. Since the random sample would need to be considerably larger, the expense involved in obtaining this information would be many times higher. This is particularly evident if we take the manure spreader, balers, telehandlers and combines as examples. No distinction was made for any type of machinery as regards the make of the machine or its fittings. Nevertheless, where some machine types are concerned, such a distinction would be necessary in order to take into account the high level of heterogeneity of the machines (balers, precision seed drills, forage wagons/silage trailers, telehandlers/yard loaders/wheel loaders).

It is noticeable that the age of the machines indicated in the survey was sometimes way in excess of their economic service life. This explains the sometimes significantly higher costs for repairs, service and maintenance works on the machines in the survey.

The detailed account of the 130 repairs conducted on the tractors showed, on the one hand, the multiplicity of the damaging events to be expected that cannot be planned for, whilst, on the other it became clear just how frequently such events occurred. Even though an "average repair" costing 999 € is not something to be regarded as insignificant under any circumstances, the probability of the specific repairs occurring on an annual basis was relatively low at less than 5 % in each case.

The KTBL are currently looking into whether only the time- and usage-dependent maintenance and service works that occur on a regular basis should be reported. These could also be reliably calculated without resorting to expensive surveys. The basis for the calculations would then be the intervals between regular maintenance works, the frequency of service works involving the replacement of wearing parts as well as the quantity and price structures for spares and for work.

The further development of the method for determining the repairs costs is being overseen by the KTBL Working Group "Industrial Engineering and Business Management Cost Bases – Data Management" (Chairman: Peter Spandau, Chamber of Agriculture for North Rhine Westphalia). In addition, the proposals are being discussed and agreed within the framework of a working group made up of representatives from all over the Confederation. The processing of methodological questions relating to the recording and processing of data together with the documentation and standardisation of this data currently represents a focal point within this working group. In this connection, the KTBL is drawing up a quality management system which will serve as a framework for documenting the methods. It is in this context, for example, that the most recent KTBL publication "The Calculation of Performance-Related Costs in Agricultural Corporate Planning" was compiled.

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