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Effect of Mechanisation and Cultivation on Soil Condition

Various authors in professional literature frequently maintain that farmland is detrimentally compacted by big modern machinery. However, these assertions are based mostly on assumptions, since only a few references provide detailed empirical data on how soil is really impacted by cultivation. To determine this, an investigation was conducted on farms. The experimental variants were four variously stressed part-fields of arable land on 17 locations altogether. It was commonly cultivated mainland, the headland stressed by the many passes over the years, the tramlines stressed differently within the growing season, as well as neighbouring wasteland for comparison as an unused surface.

The farms were selected within Schleswig-Holstein and reflect the whole range of influences by soil types, crop rotations and mechanization. The technology distinguishes itself by middle-sized and big tractors, combines with 6-9 m cutting width, fertilizing and plant protection technology with up to 32 m working width and tippers with 8 to 24 t total mass. The experimental technology of the department enables to examine a field at a few points and in an extensive way. Pore volume and dry bulk density are proven parameters. They are complemented by the aerial conductivity and the root penetration as characteristics for the function of the soil. With a penetrometer, the profile can be measured in vertical direction and the whole field in horizontal direction. Beside the topical soil state, the long-term effects of the cultivation were also examined. Therefore the own results were compared with the investigation of [1] who analyzed the status of arable land in Schleswig-Holstein in marsh, geest and eastern hilly farmland in 1986/87 in a similar way. The topical status of the sandy loamy soils as well as the changes compared to Sonderhoffs results were published in the Landtechnik 2/2005. In this issue, the influences of sugar beet cultivation, management form and soil tillage systems are dealt with.

Sugar beets in crop rotation

Often the sugar beet harvester stands as an example of a soil-detrimenting machine. Whether lasting consequences exist by its application, is checked. The soil values are compared for fields with and without sugar beets in crop rotation, because on all farms a six-row self propelled sugar beet harvester is used. The fields with the soil type clayey sand and sandy loam are summarized to one group.

One recognizes that the pore volume and the macro pore volume are 0.5 to 1.5 % higher on the wasteland of farms with sugar beets in crop rotation (*table 1*). The higher level of pore volume and macro pore volume is likewise found on the headland and on the mainland of the field. Nevertheless, for the question it depends on the relationship. Actually on the farms with no sugar beet cultivation, all values are lower, but the differen-

Tab. 1: Comparing fields with and without sugar beets in the crop rotation

		pore volume [%]		macro pores [%]		pL at pF 1,8 [cm/s]	
area	**depth**	**with**	**without**	**with**	**without**	**with**	**without**
wasteland	10	47.6	45.0	17.1	15.0	1.13	1.07
	20	44.2	42.3	14.9	14.1	0.71	0.72
	40	40.6	39.1	12.3	11.6	0.54	0.55
	60	39.5	39.2	11.9	11.6	0.53	0.50
field	10	44.4	42.9	15.8	12.8	1.04	0.76
	20	42.7	41.6	14.8	11.8	0.65	0.62
	40	38.7	38.1	10.7	10.5	0.52	0.56
	60	39.1	39.1	11.3	10.8	0.55	0.53
headland	10	42.3	41.5	13.3	10.9	0.76	0.76
	20	40.8	39.3	12.2	8.7	0.57	0.45
	40	38.0	36.8	9.6	7.9	0.41	0.36
	60	39.8	36.6	9.9	7.7	0.44	0.48
		$GD_{10\,\%} \approx 2.0$ %		$GD_{10\,\%} \approx 2.7$ %		$GD_{10\,\%} \approx 2.7$ cm/s	

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Literatur

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ces are widely the same between field and wasteland. A stronger decrease of pore volume and aerial capacity is only found on the headland. Here the absolute values with approx. 36.7% pore volume and 7.8% of macro pore volume are very low and no explanation is in hand for this.

Generally the aerial conductivity changes less than the pore volume and the aerial capacity. The wasteland indicates that both groups have the same level. The comparison of the values shows only slight differences between both groups. In view of the very high scattering they are not significant.

Nevertheless, with the horizontal penetrometer measurement differences exist on single fields. In the access area to the former beet clamp, the headland shows a higher compaction, no matter whether the sugar beets were carried with a tipper to the beet clamp or whether the sugar beet harvester unloaded them directly. Likewise under the operating place of the wheel loader very high penetration resistances were measured. The situation might improve in future with the cleansing loader, because it is equipped with soil-friendly tyres and only one roll over occurs.

Otherwise the results do not show any lasting marks on the field, indicating a professional use of the heavy technology. However, the soil could also be regenerated, since the sugar beets are cultivated in an extensive crop rotation in Schleswig-Holstein.

Ecologically and conventionally cultivated fields

Ecological farming is considered to be good for the environment. From an agricultural engineering point of view there are reasons against this, because the soil is cultivated more often and more intensely as a result of not using plant protection chemicals and fertilizers. It is ploughed more often on the average of the crop rotation (80 to 90%) than on conventional farms (30 to 40%), because the advantages of reduced tillage cannot to be exploited. The farms were divided by the management form "ecologically" and "conventionally" for the comparison. Fields with the soil type clayey sand and sandy loam are summarized again.

It can be seen that the wasteland location of the ecologically managed fields have apparently lower values than the field (*table 2*). On the field the pore volume of both groups is in all horizons at the same level. The ecologically managed fields are only at 10 cm depth with 45 % PV very loosely packed, because they were partially ploughed in the spring and didn't settle yet. As expected the tramlines are naturally most compacted in the crumb with 40.5% PV. The subsoils are in 40 cm as well as in 60 cm depth at a same level as the field, thus not impaired. In the same way samples are taken from the hoeing lines on the ecological fields. In contrast to the tramlines these tracks are created only 1 to 3 times at dry and well suitable conditions. The row crops require narrow tyres. For soil conservation, terra- or double tyres are used. This leads to the fact that only the topsoil is compacted and in the subsoil no changes appeared.

The aerial conductivity confirms the differences are caused by the location. The disadvantages of track and headland didn't have a special effect. Comparing the partfields within a group reveals that only the expected differences appear. The wasteland is the least compacted and the headland the most. Field and tramline are similar. In view of the variability, no significant differences in the aerial conductivity show up. From these results the hypothesis of more soil conservation in ecological agriculture cannot be confirmed.

The differences in the soil tillage intensity pose the question for a plough pan. The pan can be measured with a vertical penetrometer, which is applied on all fields. Generally on all fields the high values of the strongly loaded variants attract attention, especially the tramlines close to the surface. The plough horizon shows naturally a lower firmness. With 30 cm the resistance strongly rises on all partial areas and indicates a plough pan, which however is to be explained by the very loose cultivated horizon, because in the subsoil the curve is at a similar level with the wasteland. On most fields one cannot conclude on compaction, because in the whole survey, only 40 percent of all locations with the soil type sL and lS show a plough pan, which is noticed as blurred in the profile. It is found on conventionally as well as on ecologically managed fields. There are distinct differences only between ecological hoeing lines and the conventional tramlines, because the tramlines are much more compacted in the topsoil. This was not to be recognized with the core cylinder measurements.

Result

All in all no distinct relations existed between the sale of the mechanization, the soil tillage and the soil properties can be identified. The results do not allow concluding that agricultural land is damaged to a disastrous degree and that the lasting protection of the soil is at stake. This can calm on the one hand, but should not to lead to abstain from the principles of good soil-saving practice.

Tab. 2: Comparing conventionally and ecologically cultivated fields

		pore volume [%]		macro pores [%]		pL at pF 1,8 [cm/s]	
area	depth	with	without	with	without	with	without
wasteland	10	47.0	44.5	17.2	14.2	1.17	0.67
	20	43.6	42.7	15.2	13.6	0.74	0.46
	40	40,5	37.7	12.8	10.3	0.55	0.40
	60	39.7	38.5	12.8	9.5	0.54	0.34
field	10	43.5	45.1	15.1	14.5	0.90	0.67
	20	42.4	42.1	14.4	12.0	0.68	0.42
	40	38.3	39.1	10.9	12.2	0.50	0.57
	60	39.1	39.7	11.4	12.1	0.56	0.36
tramline	10	38.3	40.1	8.5	8.8	0.34	0.33
	20	39.4	42.8	10.2	12.4	0.40	0.43
	40	38.2	38.0	10.0	15.1	0.50	0.59
	60	39.9	38.8	12.1	17.1	0.53	0.90
headland	10	41.6	44.0	12.8	12.4	0.70	0.82
	20	39.7	42.4	11.5	9.3	0.51	0.40
	40	37.0	40.6	9.6	8.6	0.38	0.34
	60	38.4	38.9	9.9	7.5	0.46	0.35
		$GD_{10\,\%} \approx 2.3\,\%$		$GD_{10\,\%} \approx 2.9\,\%$		$GD_{10\,\%} \approx 2.4$ cm/s	

Literature

Books are identified by •

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