Michael Weißbach, Kiel

New tyre concept for protection of soil structure

Throughout agricultural engineering an increasing application of powerful machines is to be seen. This applies to tractors as well as transport vehicles and implements. High net and load weights are supported by large-volume tyres. A considerable proportion of these machines lie, however, at the limits of the permitted total width so that a compromise between permitted total width and optimum tyres has to be found. New tyre concepts involving widths of 900 mm offer an interesting solution.

Total weight rises along with the engine performance of tractors. Thus, 175 kW tractors support up to 5 t per wheel on the rear axle. On top of this, modern tractors allow travelling at 50 km/h on the roads.

Regarding tyres, focal point with roadwork is safety, wear and comfort. Out in the fields, soil protection and draft transference are the main points.

Air pressure plays a central role. Contrary to slow on-field driving, pressure under consistent wheel loads must be raised with rising speed to avoid overload damage on the tyres.

In fieldwork, dual and Terra tyres are standard in many areas. High loads are thus spread over a large area and the sensitive soil only minimally stressed. Furthermore, the wheels assume the role of seedbed consolidators over the working width. With very large working widths, triple tyres can be fitted for this reason. Dual wheels are often preferred to Terra tyres because the tractor thus remains universally applicable.

Especially with powerful tractors a conflict of aims appears: the total width with dual or Terra wheels of over 3 m is not on the road. Application is therefore limited to land around the steading.

The different field pressures required for field and road work uncover another problem: because of the current lack of practical tyre pressure controlling equipment, tractors work the fields with high, road-suitable, tyre pressures.

With the new 900 mm tyres, the high demands for soil-protection and roadwork are claimed to be combined. The tyres exploit fully the mandatory vehicle limit of 3 m total width. Currently, three sizes are available: 900/50R42, 900/55R32 and 900/60R32. The different dimension can replace the usual tyre sizes used previously, as demonstrated by chosen examples in *table 1*.

The load carrying capacity of the 900 tyres is higher than with those tyre sizes used up until now, this can be seen especially clearly with tyres using higher air volumes (900/65R32).

Self-propelled harvesters, especially those with bunkers, put substantially higher wheel loads on the ground. On the contrary to tractors, the high loads occur only at low speeds and in cyclical field operations. With tyre width and air volume in the tyres rises also their load carrying capacity. This enables driving with low air pressure, even with heavy loads. To be emphasised here is that the narrower 900 mm tyres (900/65R32) show the same carrying capacity as 1050 mm broad tyres.

New tyres in test .....

The new tyres promise advantages in soil protection as well as in draft power. For this the ground pressure in natural soil was measured. Here, the pressure progression reflects the effect which in the end influences soil structure. Hosepipe sensors inserted at various depths in an appropriate number of replications (n =4) were used for recording

Table 1: Comparison of 900 tyres with previous equipment (wheel load 4.5 t, v= 50 km/h)

	Air pressure [bar]	Comparative sizes	Air pressure [bar]	Carrying capacity
900/55R42	1.2	650/65R42	1.6[1)]	+23 %
		710/70R38	1.4	+6 %
900/65R32	0.8	650/65R42	1.6[1)]	+60 %
		710/70R38	1.4	+40 %

[1)] Permitted speed with this wheel loading is only up to 30 km/h

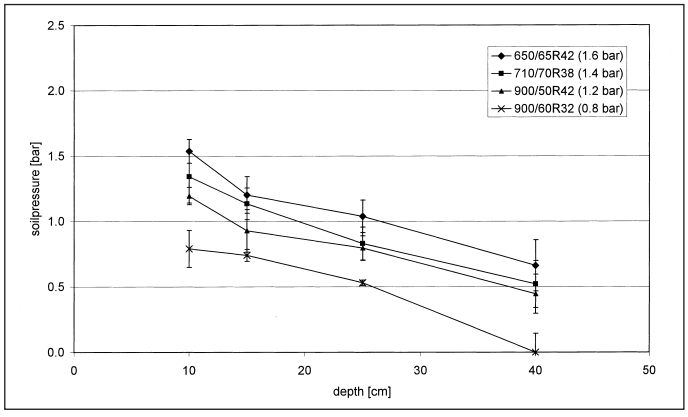

Fig. 1: Pressure in the ground under broad tyres of same load capacity of 4.8 t

Dr. agr. Michael Weißbach is scientific assistant at the Institute for Agricultural Technology, Kiel University, Olshausenstraße 40, 24098 Kiel; e-mail: mweissbach@ilv.uni-kiel.de

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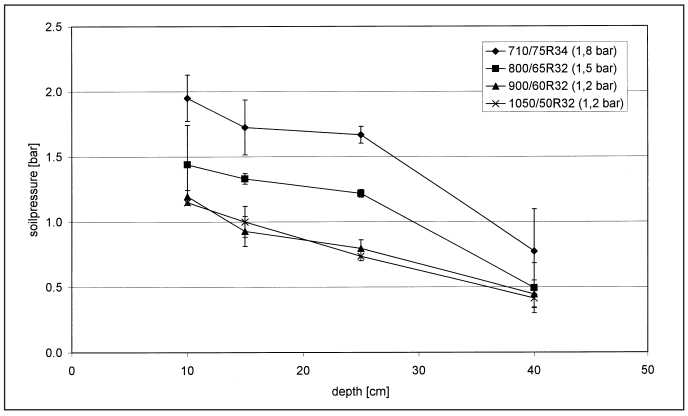

Fig. 2: Ground pressure under different harvesting machinery tyres (wheel load 8.3 t)

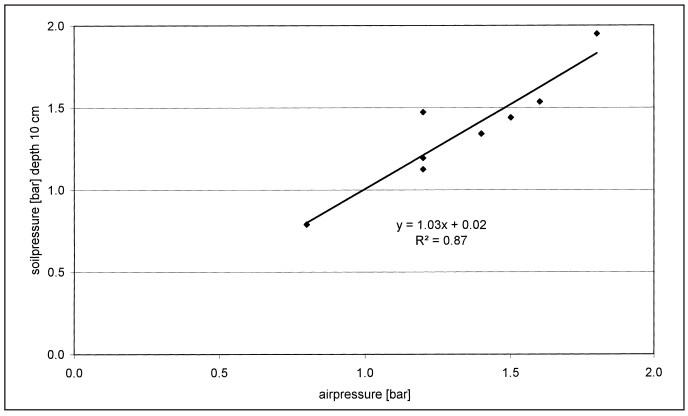

Fig. 3: Influence of air pressure on ground pressure

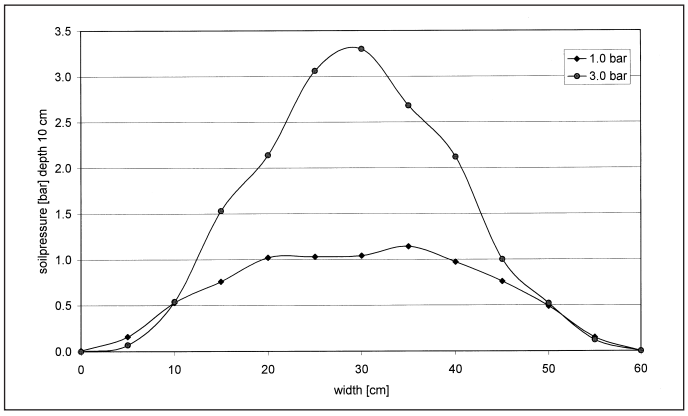

Fig. 4: Effect of non-matched air pressure (tyres: 20.5R24, wheel load 4.5 t)

the progression of pressure. The tyres could be mounted on the ballasted tractor for such measurements. However, this method of measurement negatively affects direct comparison of the tyres because the front wheels have already consolidated the soil. Thus, measurements with single wheels are preferable. Thus, single wheel equipment already at the Institute [2] was used. The recording system covered wheel diameters up to 2.5 m and single wheel loadings up to 10 t.

The soil, a sandy loam, was prepared as if for seedbed with plough and packer. For the investigation of the harvester tyres, the same soil was chosen but in a settled condition which approximated more ground conditions at harvest.

.....with tractors

At 10 cm depth the pressure under the tractor tyre was very close to the air pressure in the tyre. From this basis the curves ran almost parallel. Because the soil was loose, the pressure over depth reduced only slowly. Thus, under the narrower 650 mm wide tyres with high air pressure a pressure of 1.2 bar was still measurable at 25 cm depth. Here, the 900 mm tyre showed advantages with higher air volumes (900/65R32). This is foreseen for use with tractors as well as with harvesters. Low air pressure led to substantially less ground pressures over the whole depth.

On loose soil, 1.0 bar pressure should not be exceeded if consolidation of the sensitive soil is to be avoided [2]. The low pressure in the deeper soil level (40 cm) of 0.5 - 0.7 bar was not sufficient to exceed the natural consolidation of the soil and so did not cause further, lasting, compaction.

.....with harvesters

Settled soil at the time of harvest can stand substantially higher ground pressures. But still, 2.0 bar should not be exceeded [3].

High wheel loadings of 8 t, typical for working machines with large bunkers, can be carried by both tyres with air pressure at 1.2 bar. With narrower tyres, the required air pressure rises.

Ground pressure measurements at 10 cm depth reflected, here too, the influence of air pressure.

Under both narrower tyres with 710 and 800 mm, the higher air pressure meant that ground pressure, especially in the field topsoil, was reduced in terms of depth only slowly. Both curves showed an almost parallel progression. Under both the broader tyres (900 and 1050 mm), a similar, almost linear, pressure progression was apparent throughout the total depth.

Pressure in lower soil areas was at a low level comparable with the results in *figure 1*. These results emphasised that, not the wheel load, but instead the pressure applied on the soil surface is decisive for deep compaction effects.

Further facts

The advantage of large volume tyres can only be fully utilised through correctly adjusted air pressure. Both parameters, air pressure and contact area pressure, are closely associated with one another (*fig. 3*). Modern tyres have very flexible sidewalls, which carry no forces. The total load is thus borne by the air volume. If the air pressure in the tyre is too high, the ground pressure also rises. To demonstrate this, the pressure distribution on a trailer tyre (24R20.5) was measured, in order to exclude the influence of the lugs.

With excess air pressure, the tyre no longer rested optimally on the field surface. Through this, pressure distribution over the contact area was deteriorated [4]. Contrary to the situation with air pressure suited to the conditions, the contact area pressure rose steeply towards the tyre centreline and, here too, approached that of the air pressure (*fig. 4*) For the effect on the ground, not the average calculated contact area pressure is decisive, but instead the maximum produced pressure on a point in the contact area.

Summary

Because of their large contact area and low air pressure the new 900 tyres help avoid soil damage. Contrary to the situation with dual tyres, the total width of the tractor lies within the limits of the road traffic act. The high soil protection effect can only be achieved with suitable air pressure. Both air pressure and ground pressure are directly related.

Literature

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