Michael Weißbach, Kiel

Soil-protecting tyres for large vehicles during manure spreading

It is important that manure is applied at the right time so that growing plants can make optimum use of it and for this are required vehicles with increasingly more performance, working widths and heavier load capacities. The loads need running gears with two or three axles resulting in the same ground being wheeled four to five times with a single pass. To assess the effect of this multi-tracking with a single vehicle, measurements were carried out with two and three axle slurry tankers.

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

Keywords

Slurry application, soil saving tyres, soil pressure

Literature

[1] *Weißbach, M.*: Bodenschutz bei landwirtschaftlichen Transporten. KTBL-Workshop „Landwirtschaftliche Transporte" 21./22.Februar 2001 Berlin, http://www.ktbl.de/pflanze/tul/bodenschutz/bodenschutz.pdf

[2] *Holz, W.*: mündliche Mitteilung, 2000

Heavy weights are transported during manure spreading with tankers carrying up to 12 m^3 with single or double axles. The twin axle bears capacities of from 5 to 20 m^3 and wheel load rises up to 6.5 t. Only 3-axle tankers are used for capacities of over 20 m^3.

The higher wheel load must be applied in a way which does not damage soil structure. For this a variety of tyres are offered of varying breadth and diameter. The type of tyre finally used depends on the breadth and the available design volumes In general the carrying capacity increases with the breadth of the tyres, with modifications according to cross sectional relationship and the wheel diameter. With a maximum speed of 30 km/h the carrying capacity increases by 800 kg for every 100 mm tyre breadth [1].

Trial variants

Ground pressure recordings were conducted with 2 and 3-axle slurry tankers with tyre pressure in each case adjusted for fieldwork. To realise higher road speeds, higher tyre pressures were required for transport. For this reason 3-axle tankers are often fitted with tyre pumps. The effect of tyre pressures too high for fieldwork was also included in the trial.

The running gear for the tractor-tanker train differed with tyres, wheel loads and tyre pressures *(table 1)*. The axle load for the tractor rear axle for the 2-axle tanker was double that of the front axle. A part of the tanker weight (up to 2 t) was supported on the tractor rear axle. Engine power and own weight of the tractor pulling the 3-axle tanker were greater. Additionally, front ballast weights increased the load on the front axle. There was a clear difference in wheel loads between the different tankers.

Through the large-volume tyres on tractor and tanker it was possible to support the higher wheel loads on a larger contact area with a lower tyre pressure. On-field the tyres on the 3-axle vehicle required a pressure of 1.2 bar, for high speed on the roads, 3.0 bar. The tyre contact area was reduced by around 40% by the higher air pressure.

Used for the recording was an area which had grown maize in the previous year and was to have slurry applied in spring. It had

Table 1: Vehicles technical data

	Tyres	Wheel load [t]	Air pressure [bar]	Contact area [cm^2]
	2-axle tanker (18.5m^3)			
Tractor front wheel	540/65R28	1.4	1.4	2290
Tractor front wheel	650/65R38	3.1	1.4	4859
Slurry tanker wheel	750/60-30.5	4.1	1.2	5570
	3-axle tanker (24m^3)			
Tractor front wheel	600/65R28	2.2	1.4	4217
Tractor front wheel	710/70R38	4.5	1.4	6596
Slurry tanker wheel	24R20.5	5.9	1.2	5650
Slurry tanker wheel	24R20.5	5.9	3.0	3380

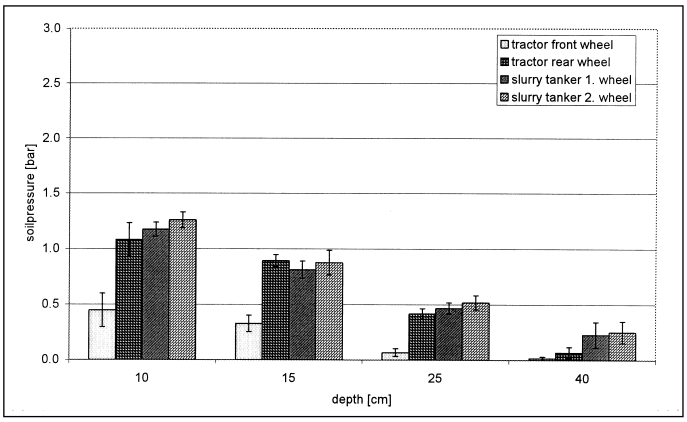

Fig. 1: Ground pressure under 2-axle slurry tanker

been fallow since harvest. Soil type was loamy-sand (lS).

Results

Ground pressure

The role of the running gear is to protect the soil and avoid lasting ground compaction damage. Pressure exerted on the ground should not exceed the inherent soil density and also be rapidly diminished with depth.

Under the 2-axle tanker the ground pressure at 10 cm depth reached 1.2 bar *(fig. 1)*. This was near the tyre pressure. Under the front wheels of the tractor the measured ground pressure was definitely lower than the tyre pressure because the load here was reduced during driving. The pressure diminished rapidly with depth under all wheels. Thus, only a few tenths of a bar were measured under the topsoil layer (40 cm). An increase in the tyre pressure was not determined with multi-tracking.

The 3-axle tanker had the greatest mass to be supported by the ground. Through the large volume tyres and low tyre pressure the ground pressure remained around that under the 2-axle tanker. Here too, ground pressure was around tyre pressure at 10 cm depth. As a result of front ballast weights, ground pressure was 0.6 bar higher than the previous example under the tractor front wheels.

The high tyre pressure with tankers had clear results. The ground pressure was almost doubled under all three wheels and was in the region of the tyre pressure, resulting in less reduction in pressure deeper in the soil. This effect could also be seen at 40 cm. The pressure rose by 0.25 bar with every wheel pass. This effect indicated an increase in compaction with every additional tanker wheel pass.

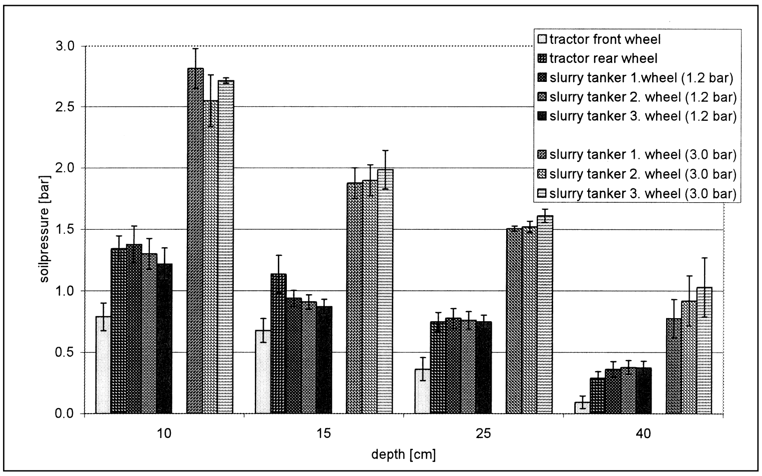

Fig. 2: Ground pressure under 3-axle slurry tanker with differing air pressures

Ground reaction

If the load exceeds the soil's inherent density the ground reacts with an increase in compaction and a reduction in pore volume. Over the total trial area the pore volume was fairly consistent at 45%. The proportion of large pores varied according to depth between 15 and 18%.

The 2-axle tanker allowed the ground to retain its undriven-on characteristics over the total depth *(table 2)*. Under the 3-axle tanker the pore volumes in the very topsoil layer were reduced slightly but did not reduce below any critical value. The values did not change under the topsoil layer.

Higher tyre pressure led to a definite reduction in pore volume right down to the levels below topsoil.

The volume of large pores reacted even more sensitively. This volume was not changed by the pressure from the 2-axle tanker and only slightly by the 3-axle tanker where low tyre pressures were used. However, high tyre pressure strongly reduced the volumes, by as much as half in the very topsoil layer and by 40% in the layer below the topsoil. Thus was shown the result of repeated tracking with high tyre pressures.

Application of tyre pumping plant

A mounted tyre pump enabled tyre pressure to be adjusted to fit the operational conditions. Low tyre pressure for fieldwork protected the soil and at the same time reduced traction requirements whilst higher tyre pressures led to notably deeper tracking with associated increased rolling resistance and draught requirement. In this context [2] has made recordings during slurry applications in spring on wet soils. The resultant 1.7 higher draught force requirement with higher tyre pressure meant a higher engine power requirement and fuel consumption. With on-field driving representing 40% of total time, the difference in fuel consumption was 6 l/h. Especially with contractors with high spreading capacity the potential for savings appear notable. A tyre pump plant in such cases appears not only sensible but also profitable.

Table 2: Pore volumes

	10 cm		15 cm		25 cm		40 cm	
	PV [%]	GP [%]	PV [%]	GP [%]	PV [%]	GP [%]	PV [%]	GP [%]
Not driven over	44.3a	15.2a	44.7a	16.6a	45.6a	14.9a	45.4ab	18.2ab
2-axle	43.6a	14.2a	45.4a	17.8a	43.5ab	12.8a	48.5a	22.1a
3-axle nLd*	42.4a	13.1a	41.8b	11.4b	42.0ab	12.8a	44.5ab	16.5b
3-axle hLD**	42.1a	4.5b	40.3b	8.1c	39.9b	7.6b	40.8b	10.3c

*Lower air pressure ** Higher air pressure

Table 3: Relationship between tyres, draught force and fuel consumption (slurry tanker 16 t)

Tyres	Tyre pressure [cm]	Air pressure [bar]	Standing area [cm²]	Track depth [cm]	Draught force [daN]
52.0 x 20	50 - 52	4.1	1130	19 - 21	4350
550/60 - 22.5	50 - 52	1.7	2140	6 - 11	2450

Tyres	Air pressure [bar]	Draught force [daN]	Power requirement [kW bei 8 km/h]	Fuel consumption [l/h]
52. 0 x 20	4.1	4350	125	43.0
550/60-22.5	1.7	2450	75	25.5

Summary

It is possible to support the higher transport weights in slurry spreading with modern running gear so that soil structure is protected. Tyre pressure plays a central role here. High loads with reduced tyre pressure and repeated wheelings must not lead to lasting soil damage.

A mounted tyre pump is necessary for combined road and field work in this respect.