

Tractor test: Suspension systems compared

The springs are sprung

Tractor seats and suspension set-ups have evolved substantially over the past few years, pushed along at least in part by legal pressure to reduce levels of vibration. For a snapshot of exactly where we are today regarding agricultural transport operations, we bring together seven 180-220hp tractors in Holland

Forty years ago tractor drivers thanked their lucky stars for a cab – any cab. Now operators are likely to grumble if there's nowhere to plug in an MP3 player and no cold box to keep their cheese sarnies from wilting. Through the intervening decades, facilities blossomed and noise levels sank, but one thing didn't change: ride comfort. Or more accurately, the lack of it.

A warning shot was fired across everyone's bows during the long brewing of The Control of Vibration at Work Regulations, which eventually came into force for new machinery in 2007. Research has shown that effective tractor suspension, however achieved, reduces the generation of whole-body vibration and boosts the operator's perception of comfort, so manufacturers have put a lot of work into finding solutions. Now all major brands offer suspension, either as standard or as an extra-cost option. Of the seven tractors tested here, JCB is the only one with axle suspension at front and rear; the other brands suspend the front axle and spring the cab.

Operator comfort is an important issue in transport work.

Photos: HR, HW

The way a tractor is driven and the work it's doing can have a much bigger influence on vibration than the differences between suspension set-ups. Still, a tractor (or self-propelled sprayer or forager) with effective suspension pleases everyone. The farmer can ask his employees to work long stints with less risk of running into legal vibration limits; the operator gets an easier life; and the tractor maker scores a significant positive towards a sale. But given the many different set-ups on offer, where do we stand in terms of comparative effectiveness?

For some answers – at least regarding transport work – we got together with Dutch magazine *Trekker* to assess and measure suspension packages from different manufacturers. It's quite important

to see what we did, and what we had, before wading into the conclusions. So please hop across to the panel 'Finding the Difference' before going on.

All clear? Good. As ever there was a snag.

We'd planned to group tractors around the 132kW/180hp mark and end up with similar weights and wheelbases, as both of the latter factors have a major impact on the generation of vibration.

We'd originally shortlisted a Fendt 800 Vario and John Deere 7730, but the respective importers actually came up with a 922 Vario and Deere 7530. The Fendt is substantially heavier than others in the group, while the Deere is the lightest and

SUBJECTIVE RIDE COMFORT

Case IH Puma 195 CVX

Unladen tractor	–
...towing a laden trailer	+
...heavy mounted implement	+
...towing an empty trailer	0

SUBJECTIVE RIDE COMFORT

Claas Axion 820¹⁾

Unladen tractor	0
...towing a laden trailer	0/–
...heavy mounted implement	0
...towing an empty trailer	0

¹⁾ Cab suspension on middle setting





Front ballast was left in place on all tractors for the trailer part of the test – pulling a 28t gross Joskin.

has the shortest wheelbase. Given the potentially upsetting effect of these differences, please keep them in mind when considering the results. Which is where we head now, starting with an overview.

Other than when driving over anything but a billiard table, terrain shocks cause the driver to move up and down, side-to-side and backwards and forwards. While movement at any point is probably in all three directions, each can be measured

SUBJECTIVE RIDE COMFORT	
Deutz-Fahr M650 Profiline	
Unladen tractor	+
...towing a laden trailer	-
...heavy mounted implement	0
...towing an empty trailer	+

SUBJECTIVE RIDE COMFORT	
Fendt Vario 922 ¹⁾	
Unladen tractor	+
...towing a laden trailer	+
...heavy mounted implement	+
...towing an empty trailer	++

¹⁾ The heaviest test tractor



FINDING THE DIFFERENCE

The test was carried out on typical Dutch farm roads. A rectangular 1.4km course was divided into sections – good, broken and badly potholed concrete – and each was assigned a target travel speed. Operators drove laps of the course and recorded their subjective impressions of ride comfort.

In a separate exercise, Ergolab Research (www.ergolabresearch.eu) measured vibration levels at two speeds over the same tracks. Speeds were either slow (constant 15km/hr apart from corners) or fast (20, 25 and 30km/hr according to section of the lap). To find subjective differences, the tractors were driven in three ways: unladen, with a mounted 3.3t Lemken cultivator, and pulling a 28t gross Joskin trailer. For measurements only

separately and its influence examined. In our transport test, horizontal (fore/aft) movement was found to be the greatest and least well controlled. Vertical movement was significant but well-controlled. Lateral (side-to-side) movement was less than fore/aft and very similar between five of the seven tractors; it's not shown

SUBJECTIVE RIDE COMFORT	
JCB 3230 Fastrac	
Unladen tractor	++
...towing a laden trailer	0
...heavy mounted implement	++
...towing an empty trailer	++

SUBJECTIVE RIDE COMFORT	
John Deere 7530 ¹⁾	
Unladen tractor	0
...towing a laden trailer	-
...heavy mounted implement	0
...towing an empty trailer	0

¹⁾ The lightest test tractor; shortest wheelbase

the unladen tractor and tractor plus Joskin trailer (3.6t drawbar load) were used. Vibration at the seat and at the cab floor were recorded in the vertical, horizontal and lateral directions, and the corrected results are shown as acceleration in m/sec². Measurements were to ISO standards.

Six of the seven tractors used 650/65 R42 Trelleborg rear tyres with matching front rubber, while the Fastrac had 540/65 R34 tyres all round. Trelleborg's specialist suggested 1.8 bar/1.5 bar front/rear pressures best matched the test conditions, while the seats – all Grammer, though different types – were adjusted by each driver for his weight according to Grammer's instructions. For comparison we used an unsuspended John Deere 7820.

in this overview but does feature in each tractor's report (see page 16).

The seven suspension systems reduce vertical acceleration (movement) effectively, as graph 1 shows. By comparison, the unsprung test tractor generated much more vertical bounce at the seat. Interestingly, the seats of the JCB and Fendt didn't contribute much to, or worsen, the percentage reduction. This reflects the effectiveness of those tractors' axle/cab suspensions at filtering shocks before they reach the seat. Forward-and-back seat movement has a major impact on perceived comfort. Not

Grading system: ++ = very good; + = good; 0 = average; - = below average; -- = poor



SUBJECTIVE RIDE COMFORT	
Massey Ferguson 7495 Dyna-VT	
Unladen tractor	0
...towing a laden trailer	0/+
...heavy mounted implement	0/+
...towing an empty trailer	+

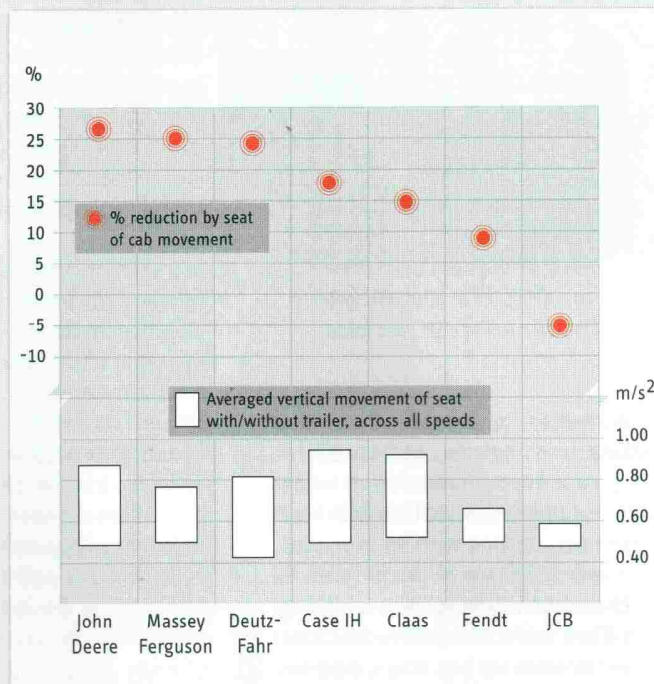


only is it generally higher than vertical movement in these tests but on average, acceleration at seat level is higher than at the cab floor – compare the red dots in graphs 2 and 3. Why is this? The seat cushion is higher than the floor, amplifying pitch. Adding a trailer produces, on average, a whopping 65% jump in fore/aft vibration, a result that won't surprise many operators; see the white boxes in both graphs.

How good a job do modern suspension systems do? To judge that, look at the unsprung tractor in graphs 2 and 3. Average movement at the cab floor was worse with no suspension. Yet for some tractors it was not that much worse at the seat (graph 3), thanks to the substantial negative impact of towing a heavy trailer. There's the broad picture of what the numbers say about suspension effectiveness. So what did the test drivers' highly sensitive nether regions make of it? Info came from five operators. Beyond laps with the tractor and tractor/trailer, tours

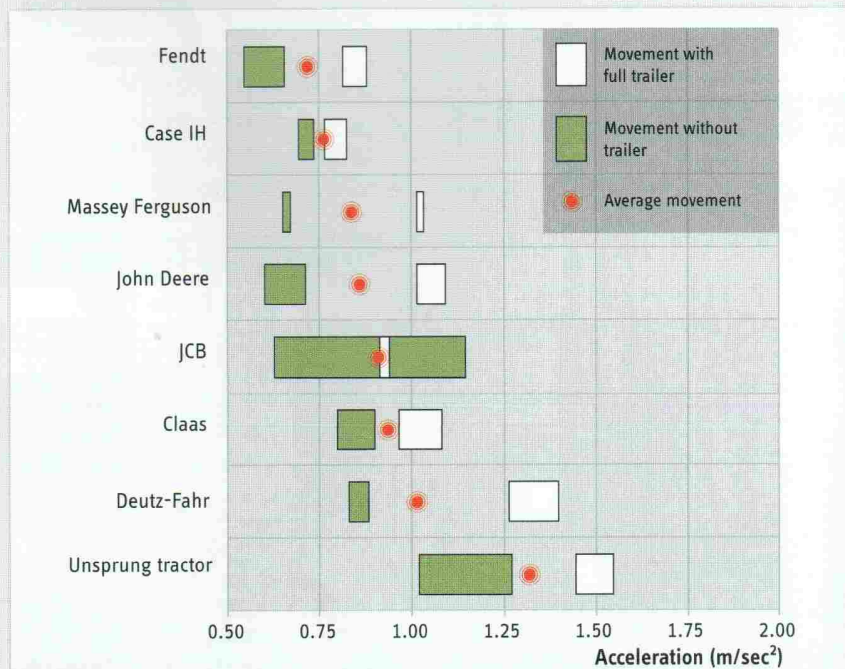
Each tractor drove down the test course, once with a laden trailer and then with an empty trailer.

GRAPH 1: VERTICAL SEAT ACCELERATION



The sprung tractors controlled vertical seat movement (white boxes), and their seats tamed vertical movement of the cab floor (red dots). In contrast, the unsprung tractor's seat suspension amplified floor movement and allowed large vertical movements.

GRAPH 2: HORIZONTAL ACCELERATION AT CAB FLOOR



Acceleration (vibration) in the direction of travel, at the cab floor (graph 2) and at the seat cushion (graph 3). Red dots are the average of runs with and without a full trailer. The further apart the green and white bars, the bigger the effect of adding the trailer. Averaged movement at the seat is greater than at the floor ...

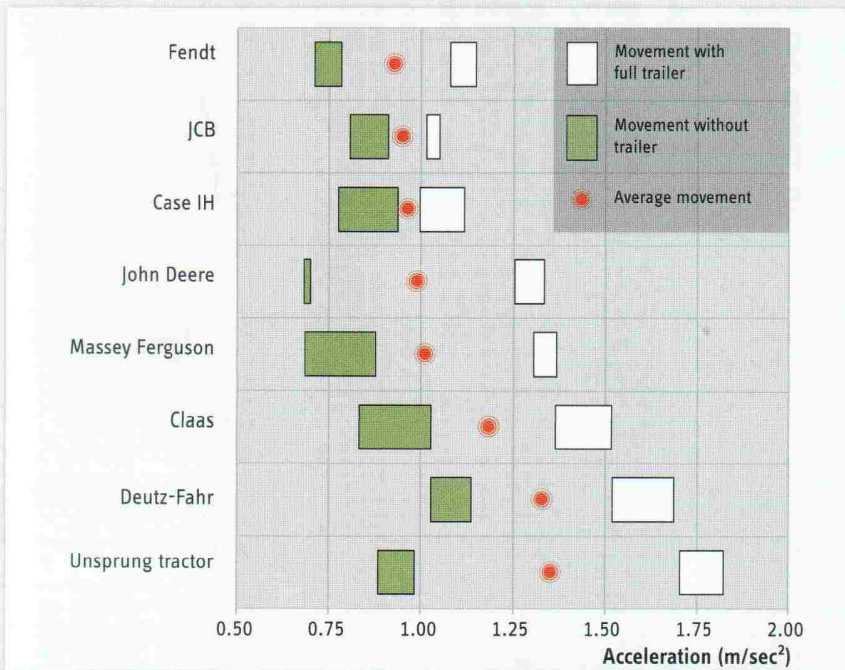
Another test section involved travelling with a heavy implement mounted on the rear linkage. Front ballast was added to every tractor.

Data and Measurements compared

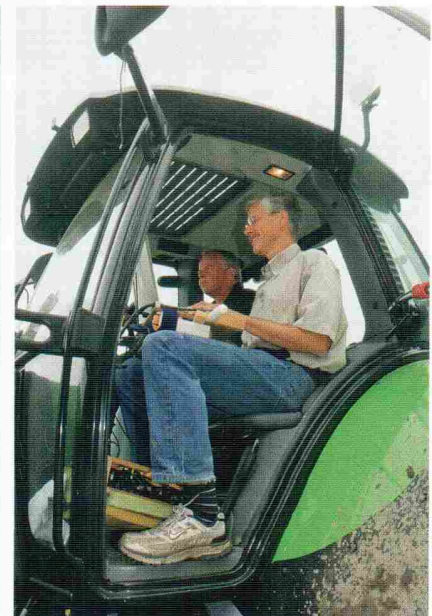
Manufacturer Model	Case IH Puma 195 CVX	Claas Axion 820	Deutz-Fahr M650 Profiline	Fendt Vario 922	JCB 3230 Fastrac	John Deere 7530	MF 7495 Dyna-VT
Rated power	145kW/197hp	135kW/183hp	133kW/181hp	158kW/215hp	162kW/220hp	136kW/185hp	140kW/190hp
Wheelbase	288cm	298cm	277cm	305cm	306cm	269cm	299cm
Weight	8,400kg	8,620kg	7,500kg	10,380kg	7,980kg	7,260kg	8,040kg
Weight on front axle	42%	45%	43%	44%	55%	37%	43%
Height to ...cab floor	149cm	155cm	157cm	157cm	138cm	145cm	148cm
...seat cushion	205cm	208cm	207cm	213cm	195cm	199cm	203cm
Front axle suspension							
Type	Hydro-pneumatic	Hydro-pneumatic	Hydro-pneumatic	Hydro-pneumatic	Mechanical	Hydro-pneumatic	Hydro-pneumatic
Suspension rams	1	1	2	2	–	2	1
Grease points	4	2	0	0	–	2	2
Damper settings	3	1	1	1	1	2	1
Cab suspension							
Type	Mechanical	Mechanical	Air	Air	–	Hydro-pneumatic	Air
Mountings	2	4	2	3	–	2	2
Front mount	Rubber bush	Coil spring/damper	Rubber bush	Air spring/damper	Silent block	Conical rubber block	Rubber bush
Rear mount	Coil spring/damper	Coil spring/damper	Air springs/dampers	Air springs/dampers	Silent block	Rams/dampers	Air springs/damper
Adjustment positions	5	3	None	None	None	None	2
Grammer seat type	MSG 95 G	MSG 95 AL	MSG 95 AL	MSG 97 EAC	MSG 95 A	MSG 95 AL	MSG 95 AL
Cost	Std	Std	Std*	Std	Std	£6,868	Std

*Deutz mechanical cab suspension is standard; air self-levelling is £875 extra

GRAPH 3: HORIZONTAL ACCELERATION AT SEAT



... suggesting that seats amplify, not quell, vibration in this direction. Note: The JCB cab is not suspended. When comparing tractors, keep in mind the Fendt's mass and the Deere's light weight/short wheelbase: as outlined in the main text, we originally shortlisted a Fendt 800 and JD 7730 but ended up with a Fendt 922 and JD 7530.



A team of operators gathered the test data.

were made with an empty trailer and with a heavy mounted cultivator. After each run the driver noted impressions, which are summed on the opening pages. The seats of our pants and the accelerometers disagreed in two cases. Overall the Deutz felt more comfortable than measurement



Vibration at the seat and at the floor were recorded.

suggested, while the Deere came across as harsher. Why is hard to pin down; perhaps it was subconscious influence, born of seeing a busy Deutz front axle against the less obviously-active Deere item.

Summary: In these transport-only tests, fore/aft seat movement was found to dominate, rising with forward speed and when pulling a trailer. Compared with an unsprung tractor, the seven chassis/cab

WHERE TO GO FROM HERE?

Current suspension systems do a good job but have their limits. One avenue to improvement is semi-active cab suspension. Valtra, Claas and others offer such set-ups: based on proven two- or four-point cab springing, semi-active control adds sensors and fast-response variable-rate dampers to tailor (and predict) cab movement to changing conditions. Although asked, makers did not supply systems for test. Semi-active seat suspension is available

from Sears and is an option on some brands. This, too, replaces a conventional damper with a controllable, quick-acting variable-rate unit so vertical seat movement can be better matched to actual and predicted conditions. Deere's version goes one stage further, controlling vertical movement in an air-sprung seat by high-pressure hydraulics. We drove with and measured Deere's 'Active Seat' as a separate exercise – watch this space for the results.

suspensions compared reduce vertical acceleration substantially at the driver's seat, and cut forward/backward movement at the floor. But fore/aft movement is worse at the seat cushion than at the floor, suggesting that where suspension lets the tractor pitch, seat suspension can actually make things worse. Which begs the question: Shouldn't components be developed as a whole-tractor solution?

Note: When comparing results via graphs

1-3, take into account the advantageous weight of the Fendt and the low mass/short wheelbase of the John Deere.

Detail on the individual tractors follows. When looking at the vibration graphs, please note the differences in their scales. Each shows the tractor's average vibration value inside a red dot, which is placed on a line spanning the group's lowest and highest values. BvH, HW

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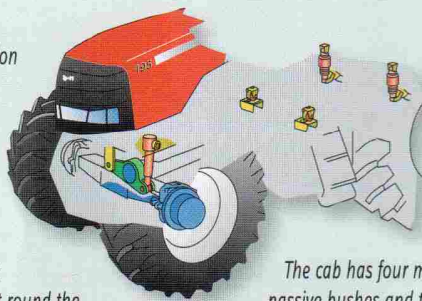
CASE IH PUMA 195 CVX

Given ballast on the front linkage, subjectively the Puma CVX was in the leading group when pulling a loaded trailer and carrying an implement. Front axle springing and the cab suspension work together well, and the suspension's full travel can be exploited with either a trailer or attachment, but solo travel without front weight is substantially harsher. This comes down to the front suspension, which stayed stiff even on its softest setting; Case says this will change. Stability over rough tracks with a cultivator on the back is excellent,



thanks to effective hitch damping and weight transfer off the nose. The tractor's MSG 95 G seat was the only one in the group that didn't adjust automatically to the driver's weight, yet all test operators agreed that the design served up good comfort.

Semi-active front suspension is standard on the Puma CVX 195 and is the same as that offered on some New Holland and Steyr models. It uses a double-acting ram working between the front tombstone and a link pivot round the axle, backed up by sensors, an accelerometer and an ECU; springing comes from a gas



accumulator. Damping is adjustable in three steps, and the system can anticipate movement from braking or acceleration. The set-up adds four grease nipples.

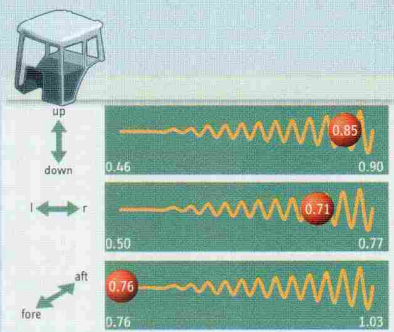
The cab has four mounts, the front two being passive bushes and the rear two spring/damper units. Five settings are on offer, though adjustment is not easy to make so is less likely to happen.



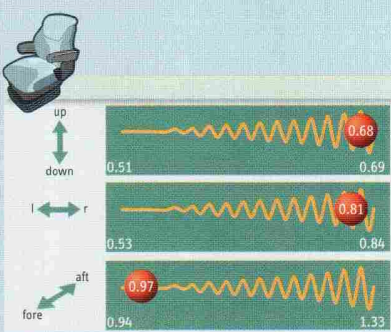
Grammer's MSG 95 G seat is basic in this company, in that it does without auto weight adjustment; otherwise it's much the same as the others. Movement range is large and the drivers loved it.



The latest Case IH set-up gives three front axle settings, but we couldn't notice much difference between them. Without front ballast the axle barely deflects; with ballast it comes to effective life.

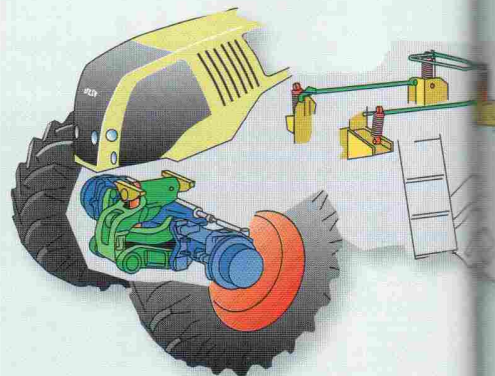


Vertical vibration isn't absorbed well by the Puma's suspension or seat. Lateral movement is average. But fore/aft vibration at the cab is lowest of the lot, possibly thanks to Case IH's semi-active axle damping.

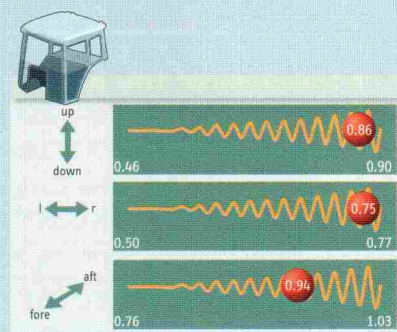


CLAAS AXION 820 CMATIC

The Claas Axion posted vibration values that were worse than average. The prime reason was roll and lively movement from the cab, which sometimes caused the operator to hold on to the steering wheel and took some getting used to. Subjectively the standard seat and cab suspension sometimes seemed to fight each other, and the seat needed adjustment from the expected settings to stop it bottoming and topping-out: a semi-active version is optional. The front axle suspension set-up contributes little when travelling solo, but was a very evident help with a loaded trailer or a rear implement despite occasionally



Suspension is adjusted by altering clamps and location holes on both sides of the cab. Tests used the default middle position; adjustment may have altered performance.



Claas's long-serving four-point cab suspension does take out extreme shocks, but overall its ...



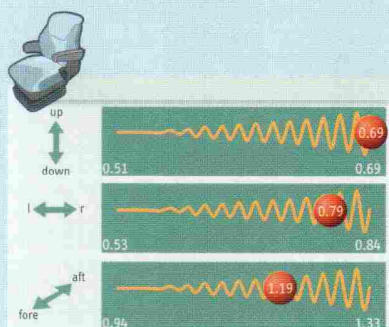
topping out at speed. The hitch damping works well, too.

Claas is said to be developing a more advanced cab suspension system, which may tackle the currently flawed interaction between the front axle springing, cab suspension and seat.

The front axle is carried by a trailing parallel linkage, using a single ram for suspension and damping. The axle comes from Dana, brings two extra grease nipples and its suspension can be switched off from the cab. Massey Ferguson uses much the same set-up on its 7495 Dyna-VT. The Axion is alone in suspending its cab at each corner, with a combined coil spring/damper unit and link rods to limit fore/aft movement and roll. Suspension firmness is adjustable in three steps, but it needs tools and is not a quick job.



Front axle suspension can be switched on and off when the tractor's travel speed is below 14km/hr.



... performance is below average. The firm is in the process of developing a new cab suspension system.

DEUTZ-FAHR AGROTRON M650 PROFILINE

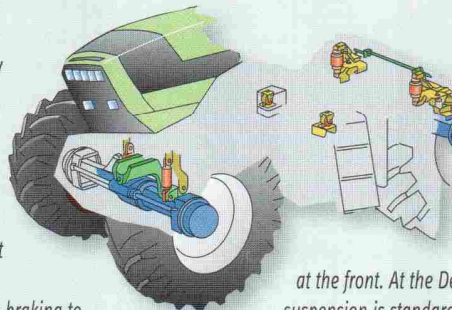
The Deutz was a big surprise in this test in two ways. The positive one was the overall effectiveness of its front suspension when travelling light. In contrast, the negative one was the way that long-travel front suspension produced a lot of fore/aft movement, with

the result that both the cab and seat hit their limit stops in rougher areas of the test track when pulling a heavy trailer at speed. This might be cured by better integration of the various components. Deutz-Fahr does have a semi-active cab set-up, although this option was not put forward for testing.



Better news is the rear linkage's adjustable damping. Test performance with a mounted implement was excellent once the system was understood, not least because the change in weight distribution lifted some load off the front axle. However, rear damping response to adjustment was not always as expected.

The front axle is cradled by two short link arms, each with its own hydro-pneumatic ram. The user can switch front suspension on and off from the cab. Setting is not adjustable, but stiffness increases automatically on braking to limit pitch. Position control can also be deactivated between 2km/hr and 10km/hr.



Front suspension adds no extra grease points and is standard on Agrotion M tractors. Cab suspension features two passive rubber bushings

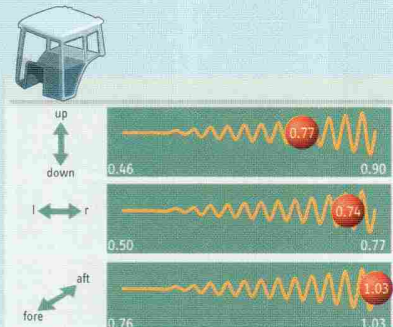
at the front. At the Deutz's rear, mechanical suspension is standard in the UK with air suspension optional. The air set-up provides self-levelling so adjusts to operator weight.



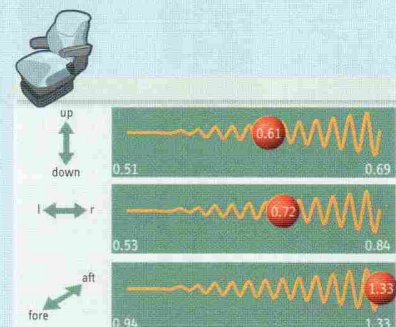
The Agrotion's switchable front suspension has no setting options, which keeps life simple.



The cab's front corners are carried on rubber bushings, which double up as pivots.



Vertical vibration, and to a lesser extent lateral vibration, are handled well. But front/rear movement at the cab floor and at the seat can be extreme. On test, the Agrotion rode better than its results suggest.

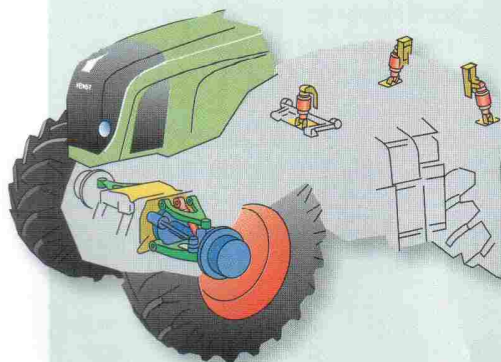


FENDT 922 VARIO

Fendt's 922 performed best of the conventional tractors. That said, the 922 was also the heaviest by a whopping 1,760kg – well beyond the next-weightiest Claas. Its independent front suspension and three-point cab mounting provided a stable ride with very little pitching. But the seat – the optional Grammer Maximo Evolution Active – was disappointing. It sets itself to the driver's weight auto-



matically yet couldn't cope with rapid-fire shocks, showed significant vertical movement and could also top out at the higher travel speeds.



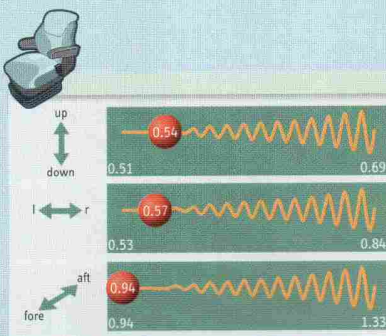
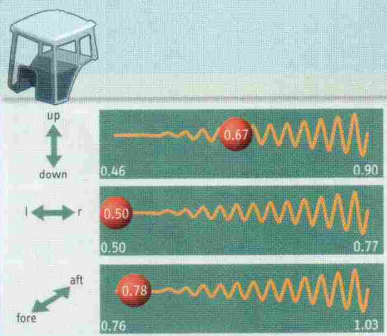
The Fendt 922 Vario features car-style wishbone independent front suspension. Springing comes from a single ram on each side, and the system offers plenty of travel. Front suspension is switchable and, when auto mode is off, the operator can set ride height manually. The set-up adds no extra grease points. Cab suspension is also standard. Unusually this uses a triangle of air springs: two at the rear and one up front. It self-levels but there are no adjustments.



Fendt's independent front suspension offers class-leading 320mm travel. Ride height is adjustable when auto mode is off and the machine is stationary.



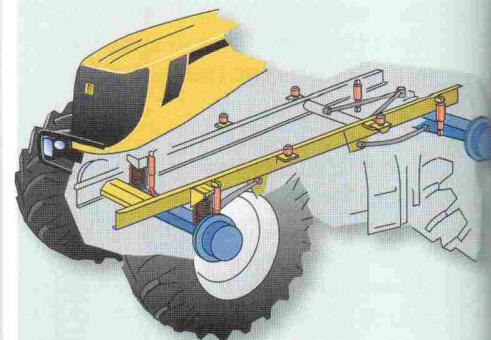
Grammer's Maximo Evolution Active seat has suspension in all planes and adjusts itself to the user's weight. Despite this, test operators weren't overly impressed by its performance.



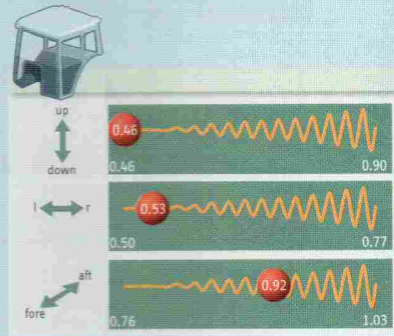
Overall, the Fendt 922 Vario delivered the lowest vibration in the test, partly through its extra mass – we asked for a lighter 800 – and partly thanks to first-class suspension. Fore/aft movement at the seat was very low.

JCB 3230 FASTRAC

The Fastrac topped the subjective scores when travelling solo and with an implement. But a hefty trailer made it bounce like a conventional tractor. JCB reckoned that this could have been down to the over-heavy 1.6t front weight compressing the front suspension and restricting its movement. Without it, 55% of the solo tractor's mass is on the front axle. Cab suspension is from rubber blocks, which seem to let tyre vibration into the cab. Also noticeable was a stream



The coil-spring front axle has no ride height adjustment. With the supplied 1.6t front weight on the linkage, the tractor's nose sat very low.



Averaged over all tests the JCB Fastrac posted the lowest vertical and side-to-side vibration at ...

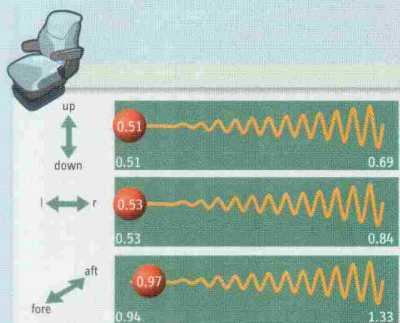


of small under-shocks, with and without a trailer, which may come from the heavy, unsprung beam axles.

The Fastrac driver sits right in the middle of the machine, between beam axles and over a chassis. The front axle is located by arms, the rear axle by arms and an A-frame. Front suspension comes from coil springs and dampers, while the self-levelling rear suspension uses strut/accumulator units. Anti-roll bars control body movement. The back axle hosts the three-point linkage. The cab is carried on relatively simple isolator blocks and is not sprung.



Rear axle suspension comes from two struts, each with a pair of accumulators. Even without a sprung cab, the JCB recorded low cab- and seat vibration.



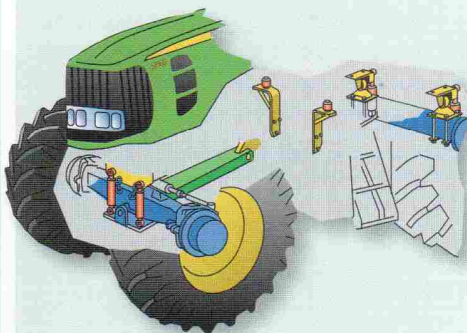
... the seat, and was only just pipped by the hefty Fendt 922 on fore/aft vibration.

JOHN DEERE 7530

John Deere's 7530 produced average results in most measurements and in the drivers' opinion. That's better than it looks, given the 7530 was the lightest and shortest tractor in the group. Its performance with the trailer was subjectively poor, with higher travel speeds introducing uncomfortable bounce. Without front weight, only 37% of the tractor's mass is on the front axle, which might explain why the front suspension didn't contribute much when travelling solo. Adding ballast and an implement brought the outfit into balance, letting



the front end work to the point that the axle could top out. Hitch damping seemed to have little effect. As on the Fendt, the JD's Grammer seat featured side-to-side suspension. Although this didn't have much effect on lateral seat vibration, the seat's ability to kill fore/aft movement was good.



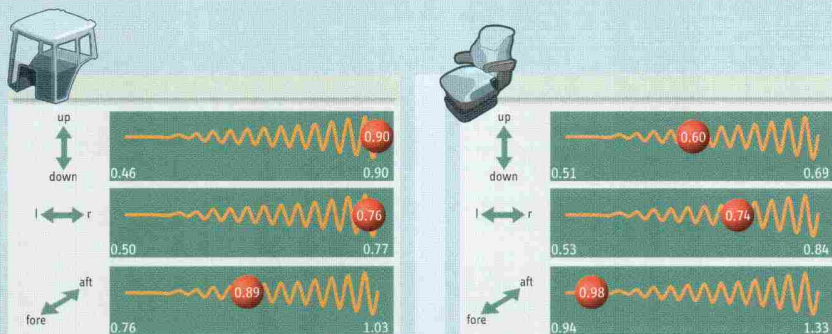
Deere's front axle is carried by a link, which pivots near the cab. Springing/damping comes from two struts and accumulators. Firmness is adjustable from the cab with a max setting for loader work plus a manual mode to help with coupling implements. The system adds two grease nipples. The front of the cab is carried passively by two rubber mounts. Self-levelling, weight-sensitive and self-adjust rear cab suspension comes from a pair of interconnected rams with gas accumulators.



Front suspension settings are made on-screen. Choices are auto mode, manual or maximum, the latter suggested for loader work.



The Grammer MSG 95 A seat features control of sideways movement, though this is not adjustable.



At the cab floor, the 'light' 7530 produced the highest vertical and second-highest lateral vibration in the test. Unpleasant front/rear vibration is lower, though, and the seat's suspension deals with it effectively.

MASSEY FERGUSON 7495 DYNA-VT



Test operators scored the Massey Ferguson's suspension slightly above the group average, which ties in with the data.

The axle response was stiff when travelling solo, but it became fluid when the tractor was ballasted and paired with an implement. Higher speeds produced

some noise from the front, possibly as the axle topped out. Travelling with a heavy trailer resulted in subjectively large movements at the seat, both in the vertical and front/rear planes.

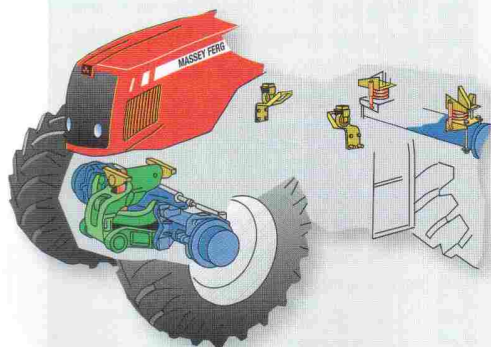
Cab suspension has field and road positions switched from in the cab, although drivers couldn't pick up a difference between settings. Overall the cab suspension felt rather wooden; while it's possible to adjust the Koni dampers, we left them on the standard setting. Adjustment needs a tool.



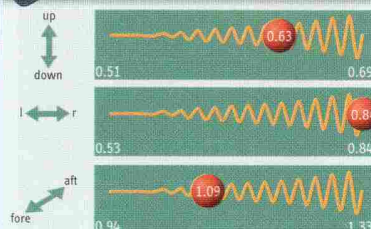
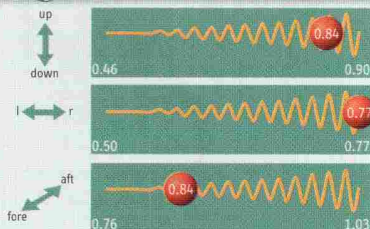
Air springs and Koni adjustable dampers at the rear handle cab suspension. Tests were carried out on factory settings.



The upper rocker switch toggles cab suspension rate, increasing air pressure for a claimed improvement in road travel stability. The lower rocker switches front suspension on and off.



The Massey Ferguson 7495 Dyna-VT shares Dana front suspension with Claas's Axion 820 CMATIC, though its cab springing is completely different. The front set-up uses three trailing arms to hold and locate the front axle, with springing provided by a single, central ram. It's standard on the Dyna-VT and adds two grease nipples to the maintenance task. The Massey's cab pivots at the front on a pair of rubber bushes, one at each corner. At the rear are two air springs plus a separate external damper for each. Air pressure can be switched between 2.5 bar and 3 bar on the move.



Vibration is high in the vertical and side-to-side directions, the latter possibly made worse by run-out noticed in one tyre. The Massey's cab floor vibration is quite low in the fore/aft direction.

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