DLG Test Report 6283F

CNH Industrial Belgium N.V.

New Holland FR 650

Fuel consumption and throughput in corn

DLG FOKUS TEST

08/15 Fuel consumption and throughput in corn

Test Center
Technology and Farm Inputs

www.DLG-Test.de

Overview

The FokusTest is a smaller-scale DLG usability test intended to allow product differentiation and special highlighting of innovations in machinery and technical products used primarily in agriculture, forestry, horticulture, fruit cultivation and viticulture, as well as in landscape and municipal management.

This test focuses on testing a product's individual qualitative criteria, e.g. fatigue strength, performance, or quality of work. The scope of testing can include criteria from the testing framework of a DLG SignumTest, the DLG's extensive usability test for technical products, and concludes with the publishing of a test report and the awarding of a test mark.

The DLG FokusTest "Fuel consumption and throughput in corn" involved a field test of self-propelled forage harvesters in corn or grass, with harvesting conditions being kept as homogeneous as possible.

This DLG test mainly examined machine efficiency (fuel consumption in l/t). However, chopping quality was also taken into account, and throughput was expected to be at a sufficiently high level to be relevant for practical use. The present test focused primarily on a comparison of various engine generations or new engine management systems respectively.

Various settings (e.g. a range of chop lengths) were applied and tested under field conditions in order to investigate the potential of a new machine or new machine feature.

As grass often does not require the full engine power of forage harvesters, agricultural machinery manufacturers have developed new engine management systems specifically designed for use in various harvesting conditions.

This machine feature has now also been incorporated into the scope of the DLG FokusTest.

Other criteria were not tested.

Assessment – Brief Summary

New Holland's new FR 650 forage harvester exemplifies that the introduction of the new FPT Tier 4 Final-compliant engines and other details has improved overall machine efficiency substantially compared to predecessor models. The DLG test "Fuel consumption and throughput in corn" collected sufficient measurement data to confirm an increase in both productivity and machine efficiency.

Fig. 2: Front view of the new FR forage harvester series
(Photo courtesy of New Holland)

Overall, higher throughput of +5% and lower fuel consumption of -21% were achieved as a result under the given harvesting conditions and with a theoretical chop length of 8mm, compared to the FR 700 with a Tier 3 engine. The comparison to the FR 650 and FR 600 with a Tier 3 engine, with the same theoretical chop length, showed an increase in throughput and reduction in fuel consumption by 19% each.
Table 1 provides an overview of measurement data for the FR 650 at various chop length settings.

Table 1: Overview of partial results of the FR 650 field test on "Fuel consumption and throughput in corn"

	FRESH MATERIAL (FM)		DRY MATTER (DM)		FIELD VALUES	
Theoretical chop length	Throughput	Fuel consumption	Throughput	Fuel consumption	Throughput	Fuel consumption
[mm]	[t/h]	[l/t]	[t/h]	[l/t]	[ha/h]	[l/ha]
4	178.8	0.66	58.0	2.04	2.8	42.5
8	227.3	0.50	77.2	1.47	3.8	29.7
12	237.9	0.47	82.1	1.37	3.9	28.6
19	248.3	0.45	84.7	1.32	4.1	27.0
25	245.4	0.46	80.9	1.39	4.0	27.9

Manufacturer and applicant

Manufacturer:
CNH Industrial Belgium N.V.

Product:
New Holland FR 650 forage harvester

Applicant:
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Belgium

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Description and technical data

The forage harvester New Holland FR 650 Tier 4f used in the DLG test was equipped with a 10-row corn header (7.5m working width). In this machine, the chopping unit, crop processor and discharge blower are driven directly via the power band. The new cabin is specifically designed for the needs of forage harvesters. It offers good panoramic visibility, sufficient space and lower in-cabin noise levels (Fig. 2). Components and the operating concept were adapted in line with the combine harvester series to create a unified feel for the entire New Holland range of harvesting machines.

The forage harvester is driven by a Tier 4 final-compliant FPT Cursor 16 six-cylinder engine (Forage Cruiser model) with 16l capacity and 480kW (653HP) power at 1700 to 1900rpm according to ECE R120. Exhaust after-treatment is handled by the well-established SCR (Selected Catalytic Reduction) system with AdBlue, which does not require EGR (exhaust gas recirculation) or a DPF (diesel particulate filter) to comply with high emission limits. The new engines have been specifically optimised for the requirements of forage harvesting and now provide consistent maximum engine power in the speed range between 1700 and 1900rpm.According to the manufacturer, the engine torque increases sharply between 1700 and 1900rpm. It is therefore recommended to operate the harvester within the range between 1700 and 1850rpm to achieve maximum productivity at low fuel consumption.

The new engine management system provides operators with three management modes, which can be selected to match various harvesting conditions.

The engine speed is automatically reduced to 1700rpm at headlands, independent on what mode is selected.

As soon as the harvester is moved back into the crop the engine speed increase to prevent blockages.

The large, clearly designed IntelliView IV colour monitor (26.5cm) gives a clear overview of the machine's various functionalities (Fig. 3).

The harvester's current performance status is displayed on the monitor (see left half of Fig. 3 with the diagram indicating the engine characteristics). The blue circle (the so-called cursor) moves across the characteristics map shown in the diagram in line with the engine's load condition. The machine's efficiency is therefore always displayed to operators to assist them in operating the harvester within its optimum range. Ideally, the machine will always remain within the green range. Operators can keep the cursor at around the 1700rpm mark by increasing or reducing their speed of travel.

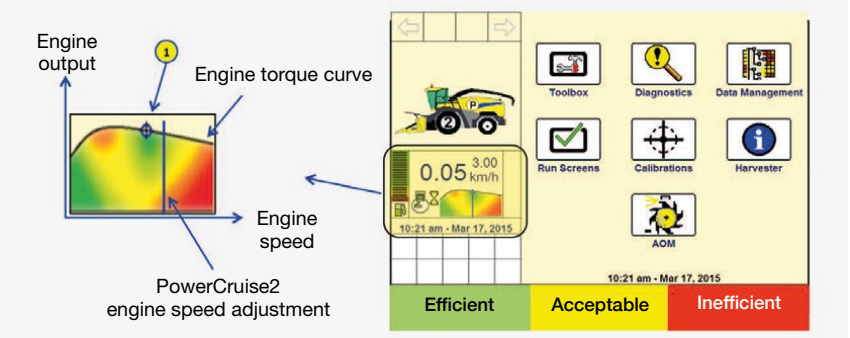

Fig. 3: ECO Mode engine management system, PowerCruise2 – extension on the IntelliView IV monitor (Image courtesy of New Holland)

Table 2:
Engine management modes of the engine management system

ECO Mode – Low engine speed range (1850 to 1700rpm), DEFAULT MODE:
– Max engine speed is limited to 1850rpm;
– Engine speed is automatically reduced to predefined rpm set point when harvesting in partial load conditions;
– Engine speed rpm set point value is configurable by operator within 1850 to 1700rpm;
– Engine speed drops below 1700rpm only if the engine load increases
ECO Mode – High engine speed range (2100 to 1950rpm):
– Max engine speed is 2100rpm;
– Engine speed is automatically reduced to the fixed rpm set point of 1950rpm when harvesting in partial load conditions;
– Engine speed drops below 1950rpm only if the engine load increases;
– This mode is not recommended, but may be required in some crop conditions*
ECO Mode Off (2100rpm), ECO MODE IS DEACTIVATED:
– Max engine speed is 2100rpm;
– Engine speed is NOT automatically reduced when harvesting in partial load conditions;
– Engine speed drops below 2100rpm only if the engine load increases;
– This mode is not recommended, but may be required in some crop conditions*

* crop conditions where high functional component speed is required (ex.: field opening in dry corn, low yield grass, grass or hay with high sugar content)

The Method

The DLG FokusTest "Fuel consumption and throughput in corn" puts a forage harvester to the test in a field trial with at least two corn varieties. Alternatively, severals forage harvesters of any agricultural machinery manufacturer can be compared.

This test was aimed at verifying the potential offered by the new Tier 4f engines in terms of reducing fuel consumption while improving machine efficiency. The test was conducted with an FR 600 and FR 700 (both Tier 3) in comparison with the new FR 650 (Tier 4f). Test drives without evaluation were completed during the pre-testing phase. These served to define chop length in consultation with the farm manager; this length was subsequently set in all three forage harvesters. The basic settings selected for the forage harvesters for the actual test were made in keeping with local harvesting conditions.

All test drives were performed successively with all three machines, with each harvester load being considered one test drive. The speed range was selected to ensure that the forage harvesters were operated within their optimum working range at average engine speeds between 1700 and 1850rpm, depending on harvesting conditions and set chop length. In this way, the objective of keeping engine loads within the optimum range of the characteristics map was achieved. The Fliegl forage trailer provided by the DLG was equipped with a calibrated weighing unit to allow the harvested crop to be weighed directly on the field. The harvest size could then be immediately analysed using the forage harvester's machine data. The monitors provided on the trailer sides (about 75 x 45cm in size) display harvest sizes directly and thus indicate how evenly the yield is distributed between the various test drives (Fig. 4).

The FR 650 and FR 600 were compared using five different chop length settings to ensure that a wide range of commonly used lengths were covered. These settings included the chop lengths of 4mm, 8mm and 12mm on the one hand, which are commonly used in Germany and Europe, and 19mm and 25mm chop lengths on the other, which cover conditions on the North American market. The FR 700 was only tested in the short chop length range (4mm to 12mm) and compared with the other two forage harvesters.

The tests were conducted using two different corn varieties to cover a broad range of potential applications. At least three trailer loads were harvested per chop length setting and test variety and compared between the three harvester models. Representative composite samples were also prepared from an adequate number of samples taken randomly once the various trailer loads had been discharged at the silo (Fig. 6 to 9). The resulting composite sample was subsequently homogenised. Three representative subsamples each were then prepared using a large and small sample divider and transferred into suitable containers. The fresh matter start weight was determined directly when filling the containers. The containers were then sealed, labelled and placed into intermediate refrigerated storage. Three subsamples from each trailer load were used to determine dry matter. Field conditions (corn variety, plant height, number of ears per plant, row spacing, maturity indices) were additionally documented during the test, and the technical quality of chopped forage was monitored.

Fig. 4:
New Holland T7 270 and Fliegl ASW 271 silage trailer combination with calibrated weighing system and trailer-side display

Fig. 5:
New Holland FR 600 in field use

Fig. 6 to 9:
Silo-side taking and processing of samples

Fig. 10:
Harvesting conditions on a test site in Saxony-Anhalt

In this DLG FokusTest, the new New Holland FR 650 (Tier 4 final) was compared with its two predecessor models, the FR 600 and FR 700 (both Tier 3) in a field trial. Table 3 contains an overview of the various harvesters' engine power ratings.

The machine was equipped with a 2 x 16 knife cutterhead and a crop processor with 99/126 teeth and a 30% speed differential. The crop processor was pre-set to 2.0mm. The new engine management system was deactivated, as the FR 600 and FR 700 models do not have this feature. These settings remained unchanged throughout all test drives.

Harvesting conditions

The field test was conducted on a field in Saxony-Anhalt during the 2014 harvesting season.

Adequately large test fields cultivated with two different varieties of corn were available at the test site (see Table 4).

The test site near Oschersleben in eastern Saxony-Anhalt contained homogeneous corn crops of both varieties, and harvesting conditions were comparable throughout the duration of the field test (Fig. 10).
While there were inhomogeneous sections, these were not included in the evaluation.

Comparison of test results: FR 650 vs. FR 600 vs. FR 700

Table 5 gives an overview of the test results. The table provides the measurement data for processing times only, excluding times taken for turning, for the entire duration of each test.

The FR 650 Tier 4f features an SCR catalytic converter with AdBlue, in contrast to the FR 600 and FR 700 Tier 3. Due to its new engine configuration, the FR 650 Tier 4f achieves greater torque and more even engine characteristics compared to the FR 600 and FR 700.

Table 3:
Overview of engine outputs of the three forage harvesters, i.e. FR 650, FR 600 and FR 700

	Engine	Capacity	Cylinders	kW/HP @2100rpm, ECE R120	Max. kW/HP @1800-2000rpm, ECE R120
FR 650	FPT Cursor 16, Tier 4 final	15.9 l	6	440/598	480/653*
FR 600	FPT Cursor TCD 13, Tier 3	12.9 l	6	405/553	441/600
FR 700	Caterpillar C18, Tier 3	18.1 l	6	470/639	504/685

* at 1700-1900rpm, ECE R120

Table 4:
Overview of corn varieties and harvesting conditions

Corn variety	Variety description	Crop	Average yield [t FM/ha]*	Test site	DM [%]* Whole plant
Scandi	Silage and energy corn for biogas, medium-early, corn ripeness index approx. 320, Caussade Saaten GmbH	Homogeneous, 3.3-3.8m plant height, number of ears 1-2, 75cm row spacing	63.1	Saxony-Anhalt	28.0 [27.5 – 28.5]
Franki	Silage and energy corn, medium-early, corn ripeness index approx. 280, kernel maturity index approx. 260, Caussade Saaten GmbH	Homogeneous, 3.1-3.6m plant height, number of ears 1-2, 75cm row spacing	62.1	Saxony-Anhaltt	33.5 [32.9 – 34.2]

* Average from harvested trailer loads; determined by oven drying method

Table 5:
Overview of test results across the full duration of the test

Theoretical chop length		FR 650	FR 600	FR 700	FR 650 vs. FR 600	FR 650 vs. FR 700
4mm	Fuel consumption [l/t FM]	0.66	0.70	0.70	-6.1%	-6.1%
	Throughput [t/h FM]	178.8	163.9	191.3	8.3%	-7.0%
	Engine speed [rpm]	1860	1770	1798	–	–
8mm	Fuel consumption [l/t FM]	0.50	0.59	0.60	-19.3%	-20.5%
	Throughput [t/h FM]	227.3	184.2	216.3	19.0%	4.8%
	Engine speed [rpm]	1685	1727	1772	–	–
12mm	Fuel consumption [l/t FM]	0.47	0.56	0.58	-19.1%	-23.4%
	Throughput [t/h FM]	237.9	193.4	223.5	18.7%	6.1%
	Engine speed [rpm]	1670	1718	1714	–	–
19mm	Fuel consumption [l/t FM]	0.45	0.51	–	-13.3%	–
	Throughput [t/h FM]	248.3	212.1	–	14.6%	–
	Engine speed [rpm]	1650	1718	–	–	–
25mm	Fuel consumption [l/t FM]	0.46	0.49	–	-6.5%	–
	Throughput [t/h FM]	245.4	216.3	–	15.0%	–
	Engine speed [rpm]	1662	1670	–	–	–

The savings potentials set out above relate to the raw test data; rounding differences may occur.

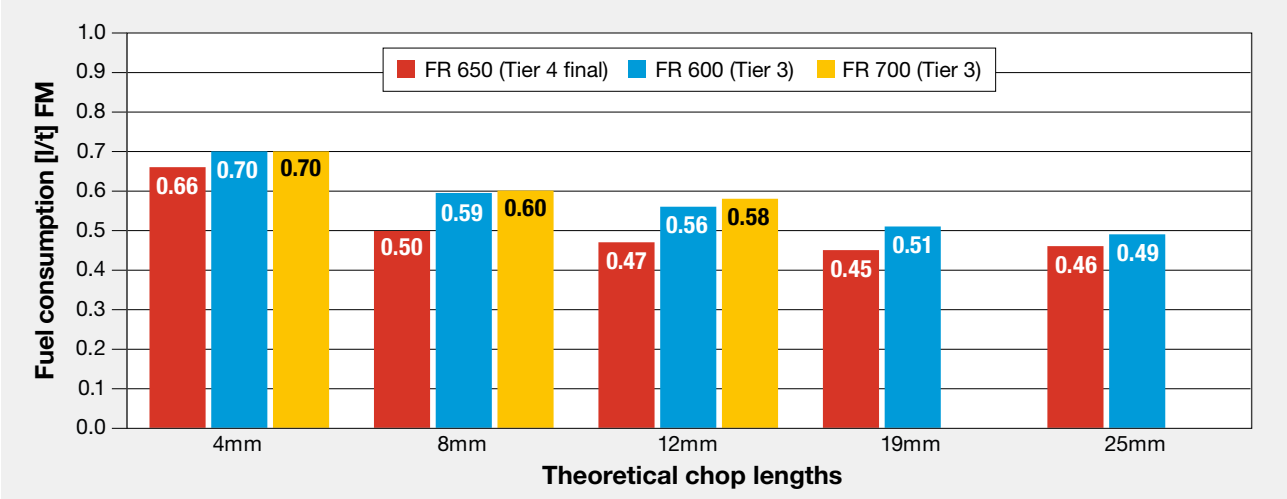

Fig. 11:
Comparison of fuel consumption values in l/t fresh material for the three forage harvesters FR 650 vs. FR 600 vs. FR 700 at various theoretical chop lengths

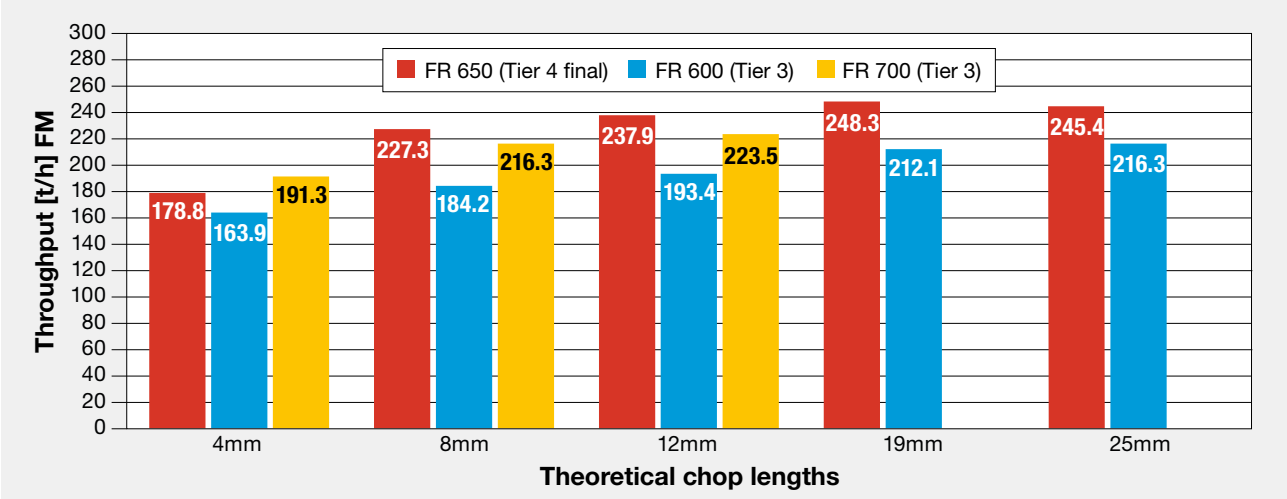

Fig. 12:
Comparison of throughput in t fresh material/h across the theoretical chop lengths of the three forage harvesters FR 650 vs. FR 600 vs. FR 700

Table 5 shows that the new generation of engine was able to achieve fuel savings of up to 21% in l/t fresh material compared to the FR 700 and 19% compared to the FR 600 with a chop length of 8mm in the above-mentioned test conditions. Throughput in t fresh material/h was increased by about 5% compared to the FR 700 and by about 19% compared to the FR 600. Refueling and calculated AdBlue consumption values indicated that the ratio of diesel to AdBlue consumption can be assumed up to 8%, which should be taken into account correspondingly. Yet fuel consumption was significantly lower, even with the higher throughput achieved, in chopping mode alone.
Fig. 11 shows a comparison of the fuel consumption in l/t fresh material for the three forage harvesters across the various chop length settings. In the short chop range (4–8–12mm), the FR 600 and FR 700 performed equally with 4mm, while the FR 600 was only slightly superior with 8 and 12mm lengths, even though it has substantially less engine power. The new FR 650 achieved fuel savings at a level relevant for practical use across the full chop length range, with the largest savings being obtained with 8 and 12mm lengths. Fig. 12 shows that the FR 650 additionally allowed greater throughput to be achieved compared to the FR 700. However, the FR 700 achieved greater throughput with the 4mm chop length. The substantial difference between the FR 650 and FR 600 results to some extent from the higher engine power, but above all from the new engine characteristics and overall machine efficiency. These advantages were also clearly evident in relation to the FR 700. The FR 650 average throughput of about 227t fresh material/h with 8mm chop length and a harvest size of more than 150t per machine across all test drives confirm both the representative nature of the measurements and the overall results.

Summary

With the new Tier 4 final-compliant engine generation, New Holland has improved the efficiency of its machine compared to the FR 600 and FR 700 predecessor models featuring engines complying with the Tier 3 exhaust emission standard. According to the measurements conducted by the DLG Test Centre, the new engine management system of the FR 650 Tier 4 final engine allows fuel savings of 21% (in l/t fresh material) to be achieved at an engine speed of 1685rpm with 8mm chop length, compared to the FR 700 predecessor model with its Tier 3 engine. At the same time, throughput was increased by about 5% without increasing diesel consumption.

Compared to the FR 600, the new FR 650 achieved an increase in throughput and a reduction in fuel consumption of 19% each with 8mm chop length.

AdBlue consumption was up to 8% of diesel consumption. The overall machine design of the FR 650, with its improved machine efficiency, new engine management system and new cabin, shows that New Holland is intending to get off to a flying start with its new FR harvester, following the success of its CR combine harvester series. The comparison between these three machines in practical use identified differences in the engine characteristics, namely a more even engine output in the FR 650 Tier 4f at corresponding engine speed ranges. The FR 650 additionally stands out through its well-organised operating console and good accessibility of the crop processor.

The Variflow system allows the machine to be easily converted from corn to grass within a few minutes, without requiring tools.

Further Information

Additional tests of mobile dry matter sensors on forage harvesters are available for download in the "Forage harvester" section at **www.dlg-test.de/ernte**.
The DLG Plant Production Technology Committee closely examines harvesting technology as part of the DLG's technical work. Information sheets and other publications produced by this volunteer technical committee are available free of charge from **http://www.dlg.org/technik_pflanzenproduktion.html** in PDF format.

Test execution

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DLG Testing Framework

FokusTest
"Fuel consumption and throughput in corn"

Field

Field applications

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The DLG

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