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Evaluation Report 425

John Deere 8820 Titan II Self-Propelled Combine

A Co-operative Program Between
ALBERTA FARM MACHINERY RESEARCH CENTRE
PAMI
PRAIRIE AGRICULTURAL MACHINERY INSTITUTE

JOHN DEERE 8820 TITAN II SELF-PROPELLED COMBINE

MANUFACTURER:
John Deere Harvester Works
East Moline, Illinois 61244
U.S.A.

DISTRIBUTOR:
John Deere Limited
455 Park Street
Regina, Saskatchewan
S4P 3L8

RETAIL PRICE:
$160,911.00 [March, 1985, f.o.b. Humboldt, 13 ft (4 m) variable speed header, 13 ft (4 m) belt pickup, 24.5 x 32 drive tires, 11.25 x 24 steering tires, rectangular opening straw walkers, hydrostatic drive, grain loss monitor, regular tooth chaffer and sieve, hydraulic accumulator, and straw chopper].

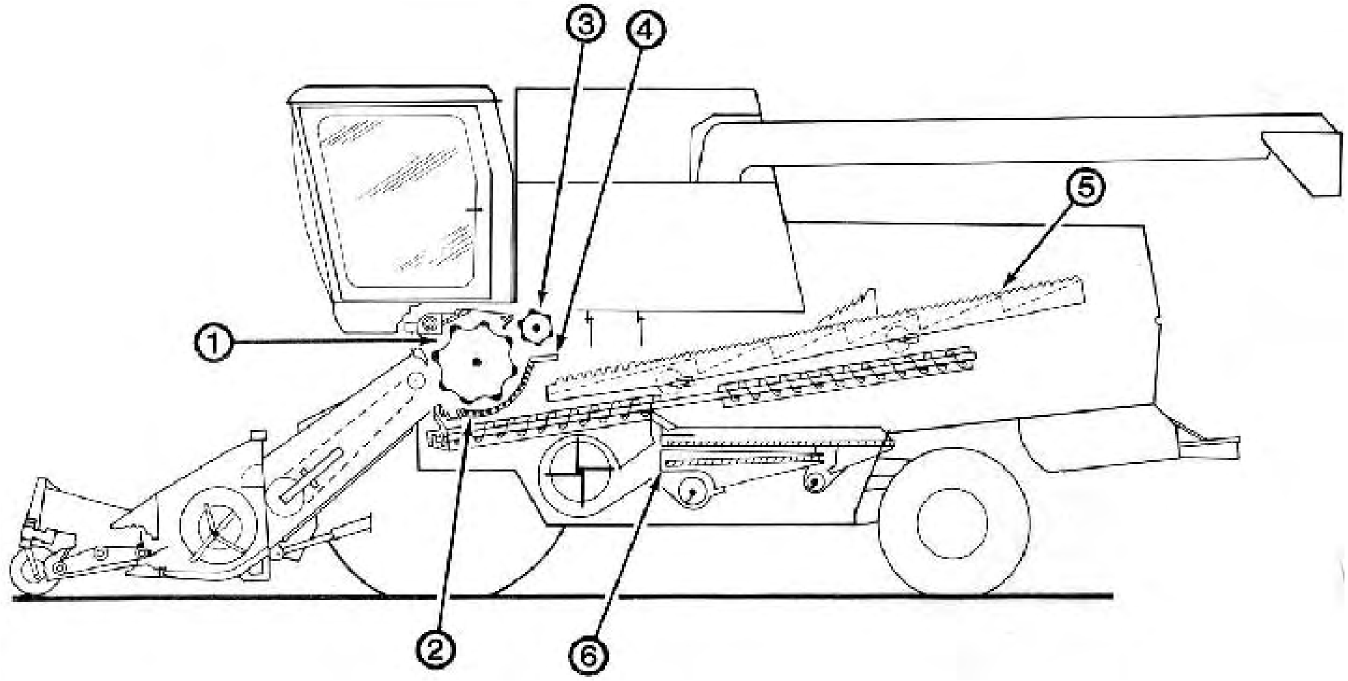

FIGURE 1. John Deere 8820 Titan II: (1) Cylinder, (2) Concave, (3) Beater, (4) Beater Grate, (5) Straw Walkers, (6) Shoe.

SUMMARY AND CONCLUSIONS

Capacity: In the capacity tests, the MOG Feedrate* at 3% total grain toss was 385 and 583 lb/min (10.5 and 15.9 t/h) in Bonanza barley. In Neepawa wheat, MOG feedrate varied from 641 to 748 lb/rain (17.5 to 20.4 t/h).

At 3% total loss the 8820 Titan II had approximately 2 times the capacity of the Machinery Institute reference combine in both wheat and barley.

Quality of Work: Pickup performance was very good in all crops. It picked cleanly at speeds up to 5 mph (8 km/h) in average windrows. The pickup fed the crop evenly under the table auger. Feeding was excellent. The table auger and feeder handled all crops well and plugged only in very severe conditions. The stone trap provided good stone protection.

Threshing was very good. The John Deere 8820 Titan II threshed aggressively in all crops. Under normal harvest conditions in easy-to-thresh crops, unthreshed losses were minimal. In hard-to-thresh crops, unthreshed losses reached about 0.5% at the higher feedrates, while grain damage varied from 2 to 4% of the clean grain.

The John Deere 8820 Titan II had good separation in all crops encountered. However, grain loss over the straw walkers usually limited capacity in wheat and barley crops.

Cleaning shoe performance was very good for most crops, but poor to fair in flax. In flax, shoe capacity was limited by blanketing of the lower sieve, seed loss over the chaffer sides, and leakage between the chaffer side and combine body. In most crops the grain sample was very clean, with most dockage consisting of undersized kernels.

Grain handling was very good. The 215 Imp bu (7.8 m³) grain tank filled evenly but could not be filled completely in canola as the seeds leaked through the screened tank walls. The unloader had adequate reach and clearance and unloaded a full tank of dry wheat in about 115 seconds. It discharged the grain in a compact stream.

Straw spreading was very good. In most crops the John Deere 8820 Titan II spread the straw evenly over 30 ft (9 m) and in ideal conditions, up to 35 ft (10.7 m).

Ease of Operation and Adjustment: Operator comfort was very good. The cab was quiet and relatively dust-free. The heater and air conditioner provided comfortable cab temperatures. The seat and steering column could be adjusted to suit most operators. The operator had a good view forward, to the left side, and of the incoming windrow. View to the right and directly behind was restricted. Instrumentation was very good. Most instruments were clearly visible and provided useful information and, or warnings for all major functions. Controls were very good. They were colour coded, clearly marked, and conveniently located. Most controls were responsive and easy to use. The optional automatic pickup height control was very convenient.

Loss monitor performance was good. Both the walkers and shoe were monitored. The display was conveniently located for easy viewing. To obtain the maximum benefit, actual losses had to be compared to meter readings and calibrated accordingly for each crop. Meter response was good for wheat and barley but less meaningful in canola and flax.

Lighting for night time harvesting was very good. Combine handling was good. The steering was smooth and responsive, however, the wheel brakes were required for picking around most windrow corners. Transport speed was slow.

**MOG refers to Material-Other-than-Grain and consists of straw, chaff, and plant residue.*

Ease of adjusting combine components was good. Ease of setting them to suit crop conditions was also good, for most crops Return tailings were easily inspected from inside the cab.

Ease of unplugging the table auger and feeder was very good. The header reverser quickly and easily backed out slugs. Ease of unplugging the cylinder was fair. Unplugging the cylinder could occasionally be done by powering the slug through, but in severe plugs the cylinder had to be rotated backwards and the crop removed by hand.

Ease of cleaning was fair. The grain tank sump was difficult to clean, the shoe delivery augers were inconvenient to clean, the sieves were difficult to quickly remove, and the complete header assembly was inconvenient and time consuming to remove. Ease of lubrication was very good as most difficult to reach points were connected to grease banks. The fuel tank inlet accepted large volume nozzles and could be filled from average height gravity fuel tanks. Ease of general maintenance and repair was good.

Engine and Fuel Consumption: The engine started easily and ran well. It had adequate power for all crops and conditions encountered. The average fuel consumption during the season was about 6.5 gal/h (29.5 L/h). Oil consumption was insignificant.

Operator Safety: The John Deere 8820 Titan II was safe to operate if normal safety precautions were taken and warnings heeded. However, adjusting the fan speed on-the-go was potentially hazardous.

Operator's Manual: The operator's manual was clearly written and provided much useful information.

Mechanical History: A few minor mechanical problems occurred during the test.

RECOMMENDATIONS

It is recommended that the manufacturer consider:

1. Modifications to improve shoe sealing to prevent grain leaks.
2. Modifications to prevent small seeds from leaking through the screen sides of the grain tank.
3. Installing a full grain tank warning device.
4. Modifications to improve the convenience of fan speed adjustment.
5. Modifications to permit more convenient cleaning sieve adjustment.
6. Modifications to carry the full width of shoe material over the rear axle to provide easier more representative checking of shoe loss.
7. Supplying a cylinder slug wrench.
8. Modifications to eliminate the potential hazard associated with adjusting the fan speed on-the-go.
9. Modifications to ensure that torque sensing hubs are adequately lubricated before shipment.
10. Modifications to prevent beater drive belt failure when power unplugging.

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THE MANUFACTURER STATES THAT

With regard to recommendation number:

1. Improvements are being implemented to provide better sealing at the front and rear of the cleaning shoe.
2. Grain tank extension screens are used to allow good visibility. Other screens with smaller openings are being investigated.
3. A full grain tank warning indicator is being evaluated.
4. This is being considered for the future.
5. There are no current plans for change in this area.
6. This is being considered for the future.
7. Dimensions for making a cylinder slug wrench (cylinder breaker bar) are contained in the operator's manual.
8. It is recommended that cleaning fan speed not be adjusted on-the-go. This should never be attempted. Changes will be made to the operator's manual to state this more clearly.
9. Procedures have been implemented to prevent any further problems in this area.
10. The lack of lubrication in the torque sensing unit contributed to these early beater belt failures. There are no current plans for changes in this area.

GENERAL DESCRIPTION

The John Deere 8820 Titan II is a self-propelled combine with a transverse-mounted tangential threshing cylinder, concave, straw walkers, and cleaning shoe. Threshing and initial separation occurs at the cylinder and concave while the straw walkers accomplish final separation of grain from straw. Grain is cleaned at the shoe and the tailings returned to the cylinder.

The test machine is equipped with a 225 hp (168 kW) turbo-charged six cylinder diesel engine, a 13 ft (4 m) header, a 13 ft (4 m) three-roller belt pickup, straw chopper, and optional equipment as listed on Page 2.

The John Deere 8820 Titan II has a pressurized and air conditioned operator's cab, power steering, hydraulic wheel brakes, and hydrostatic traction drive. The separator and unloading drives are mechanically engaged while the header drive is electrically engaged. Header height and unloading auger swing are hydraulically controlled. Cylinder, pickup, and feeder conveyor speeds as well as concave clearance can be adjusted from within the cab. Shoe and fan adjustments are made on the machine. The return tailings can also be inspected from inside the cab. Most component speeds and harvest functions are displayed on electronic monitors.

Detailed specifications are given in APPENDIX I.

SCOPE OF TEST

The John Deere 8820 Titan II was operated for 119 hours while harvesting about 1259 ac (510 ha) of various crops. The crops and conditions are shown in TABLE 1. During the harvest, it was evaluated for rate of work, quality of work, ease of operation and adjustment, operator safety, and suitability of the operator's manual. Mechanical failures were recorded.

TABLE 1. Operating Conditions

Crop	Variety	Average Yield		Width of Cut		Hours	Field Area	
		bu/ac	t/ha	ft	m		ac	ha
Barley	Bonanza	56	3.0	20, 22, 24, 42	6.1, 6.7, 7.3, 12.8	20.5	177	72
Canola	Westar	30	1.7	21	6.4	16.0	143	58
Flax	Dufferin	21	1.3	22	6.7	8.0	57	23
Rye	Muskateer	25	1.6	28, 30	8.5, 9.1	22.0	257	104
Rye	Puma	25	1.6	18, 20, 22, 24, 30	5.5, 6.1, 6.7, 7.3, 9.1	7.0	76	31
Wheat	Katepwa	34	2.3	24	7.3	6.5	62	25
Wheat	Neepawa	33	2.2	24, 25, 30, 42	7.3, 7.6, 9.1, 12.8	39.0	487	197
Total						119.0	1259	510

RESULTS AND DISCUSSION

TERMINOLOGY

MOG, MOG Feedrate, Grain Feedrate and MOG/G Ratio: A combine's performance is effected mainly by the amount of straw and chaff it is processing and the amount of grain or seed it is processing. The straw, chaff, and plant material other than the grain or seed is called MOG, which is an abbreviation for "Material-Other-than-Grain". The quantity of MOG being processed per unit of time is called "MOG Feedrate". Similarly the amount of grain being processed per unit of time is the "Grain Feedrate".

The MOG/G ratio, which is the MOG Feedrate divided by the Grain Feedrate, indicates how difficult a crop is to separate. For example, MOG/G ratios for prairie wheat crops may vary from 0.5 to 1.5. In a crop with a 0.5 MOG/G ratio, for every 100 lbs (45.4 kg) of grain harvested, the combine has to handle 50 lbs (22.7 kg) of straw. However, in a crop with a 1.5 MOG/G ratio for a similar 100 lbs (45.4 kg) of grain harvested the combine now has to handle 150 lbs (68.1 kg) of straw -- 3 times as much. Therefore, the higher the MOG/G ratio, the more difficult it is to separate the grain.

Grain Loss, Grain Damage and Dockage: Grain loss from a combine can be of two main types; Unthreshed Loss, consisting of grain left in the head and discharged with the straw and chaff, or Separator Loss, which is free (threshed) grain discharged with the straw and chaff. Separator Loss can be further defined as shoe and walker (or rotor) loss depending where it came from. Loss is expressed as a percentage of the total amount of grain being processed.

Damaged or cracked grain is also a form of grain loss. In this report the cracked grain is determined by comparing the weight of actual damaged kernels to the engine weight of a sample taken from the grain tank.

Dockage is determined by standard Grain Commission methods. It consists of large foreign particles and of smaller particles that pass through a screen specified for that crop. It is expressed as a percentage of the weight of the total sample taken.

Capacity: Combine capacity is the maximum rate at which a combine, adjusted for optimum performance, can process crop material at a certain total loss level The Machinery Institute expresses capacity in terms of MOG Feedrate at 3% total loss. Although MOG Feedrate is not as easily visualized as Grain Feedrate, it provides a much more consistent basis for comparison. A combine's ability to process MOG is relatively consistent even if MOG/G ratios vary widely. Three percent total loss is widely accepted in North America as an average loss level that provides an optimum trade-off between work accomplished and grain loss. This may not be true for all combines nor does it mean that they cannot be compared at other loss levels.

Reference Combine: It is well recognized that a combine's capacity may vary considerably due to crop and weather conditions (APPENDIX II). Since these conditions affect combine performance, it is impossible to compare combines that are not tested under identical conditions. For this reason, the Machinery Institute uses a reference combine. It is simply one combine that is tested each time that an evaluation combine is tested. Since conditions are similar, the combine can be compared directly to the reference combine and a relative capacity determined. Combines tested in different years and conditions can then be indirectly compared using their relative capacities.

RATE OF WORK

Capacity Test Results: The capacity test results for the John Deere 8820 Titan II at 3% loss are summarized in TABLE 2. The performance curves for the capacity tests are presented in FIGURES 2 to 6. The curves in each figure indicate the effect of increased feedrate on walker loss shoe loss, unthreshed loss and total loss. From the graphs, combine capacity can also be determined for loss levels other than 3%. These results were obtained with the combine set for optimum performance at a reasonable feedrate.

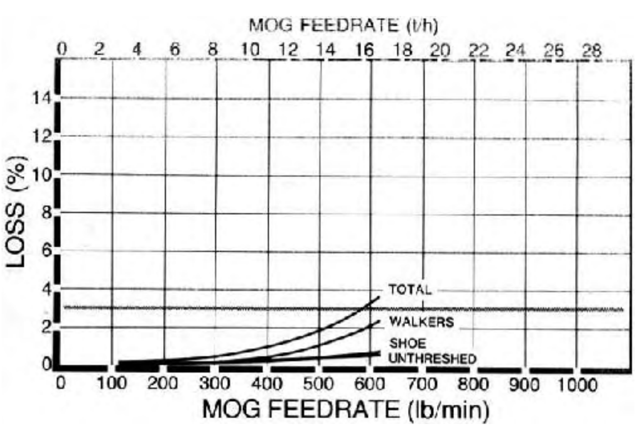

FIGURE 2. Grain Loss in Bonanza Barley (Field A - Double Windrows).

The crops for the 1984 tests suffered from extreme heat during the filling stage. Although the bushel weights were not significantly reduced, the large amount of small kernels increased the dockage. A large difference in capacity existed between the two barley tests.

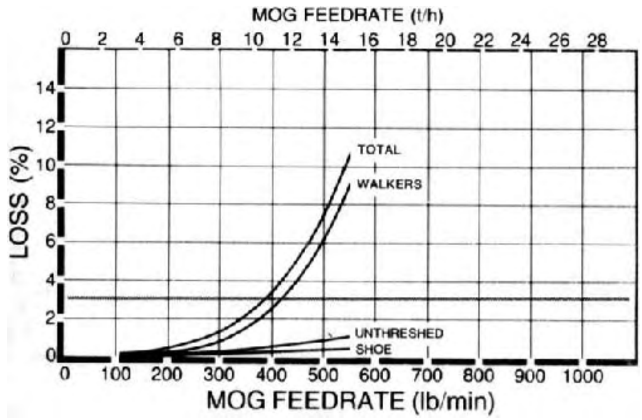

FIGURE 3. Grain Loss m Bonanza Barley (Field B - Single Windrows).

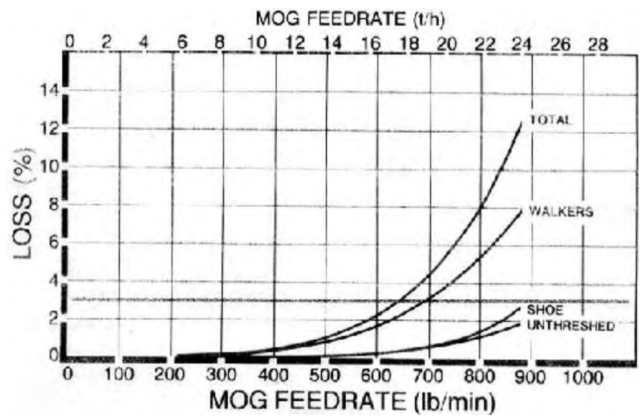

FIGURE 4. Grain loss in Neepawa Wheat (Field C - Double Windrows).

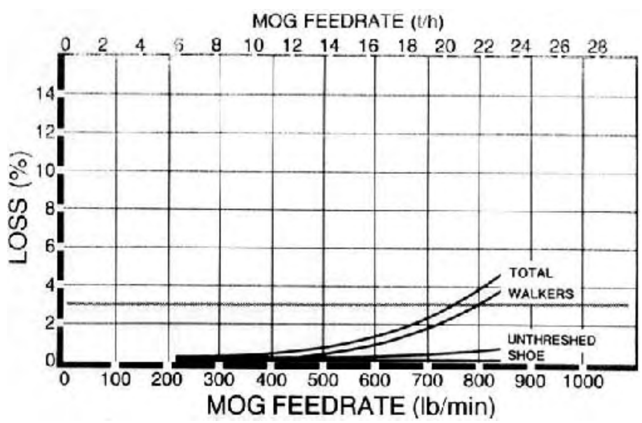

FIGURE 5. Grain Loss in Neepawa Wheat (Field D - Double Windrows).

Although crop conditions had a considerable effect, some of the difference was also attributed to the difference in windrows. The double windrow provided greater capacity as it enabled the full machine width to be used for threshing and separating. The John Deere 8820 Titan II should be operated in double windrows to fully utilize the machine's width.

The difference in capacities between the three wheat tests is attributed to the normal crop variations. The third wheat test (E) had a considerably lower yield as it was located in a different area of the province. Also, because of the crops comparatively low MOG/G ratio, it gave the combine its highest grain feedrate.

TABLE 2. Capacity of the John Deere 8820 Titan II at a Total Loss of 3% of Yield

Crop Conditions									Results						
		Width of Cut		Crop Yield		Moisture Content			MOG Feedrate		Grain Feedrate		Grain Cracks	Dockage	
Crop	Variety	ft	m	bu/ac	t/ha	Straw %	Grain %	MOG/G	lb/min	t/h	bu/h	t/h	%	%	Loss Curve
Barley (A)	Bonanza	42	12.8	68	3.7	18.5	12.9	0.77	583	15.9	946	20.6	0.3	0.7	Fig. 2
Barley (B)	Bonanza	24	7.3	85	4.6	12.0	12.1	0.68	385	10.5	708	15.5	0.8	1.1	Fig. 3
Wheat (C)	Neepawa	44	13.4	42	2.8	6.7	11.8	1.21	641	17.5	530	14.5	1.7	4.4	Fig. 4
Wheat (D)	Neepawa	42	12.8	41	2.8	8.5	10.3	1.20	748	20.4	623	17.0	4.1	6.6	Fig. 5
Wheat (E)	Neepawa	42	12.8	23	1.6	7.2	12.5	1.06	689	18.8	650	17.7	1.8	4.5	Fig. 6

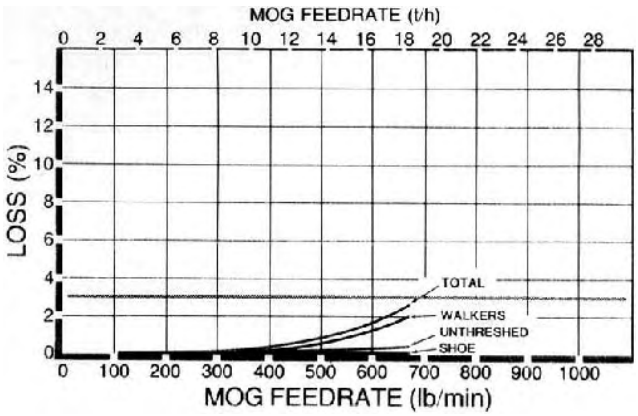

FIGURE 6. Grain loss in Neepawa Wheat (Field E - Double Windrows).

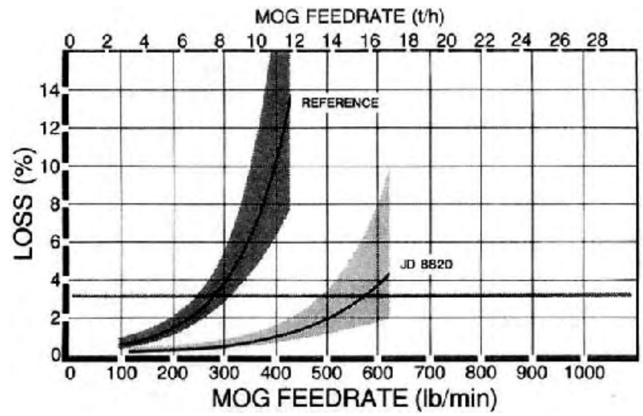

FIGURE 7. Total Grain Loss in Bonanza Barley (Field A - Double Windrows).

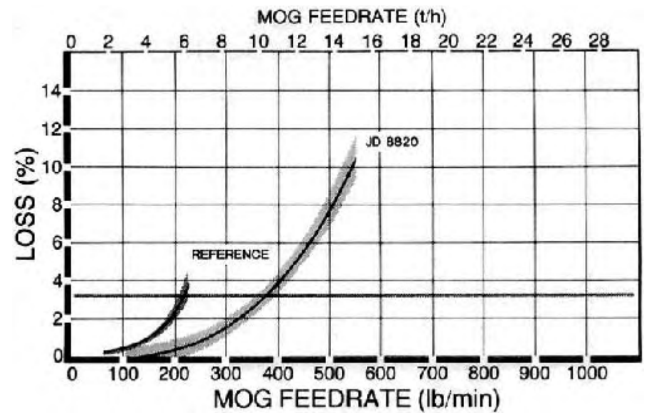

FIGURE 8. Total Grain Loss in Bonanza Barley (Field B - Single Windrows).

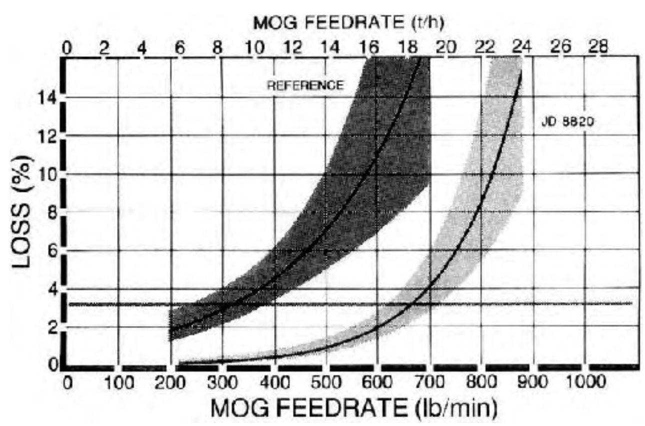

FIGURE 9. Total Grain Loss in Neepawa Wheat (Field C - Double Windrows).

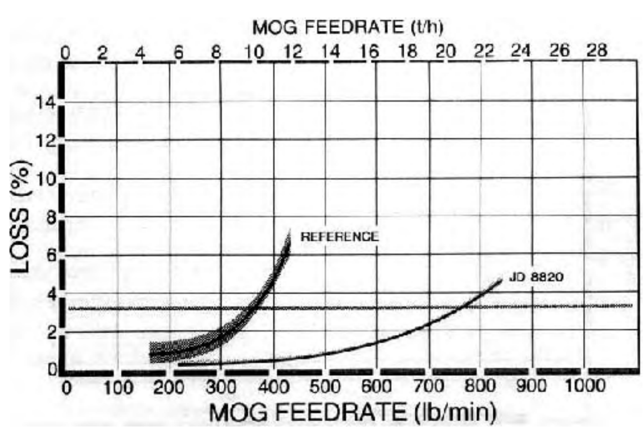

FIGURE 10. Total Grain Loss in Neepawa Wheat (Field D - Double Windrows).

Average Workrates: TABLE 3 indicates the average workrates obtained in each crop over the entire test season. These values are considerably lower than the capacity test results in TABLE 2. This is because the results in TABLE 2 represent instantaneous rates while average workrates take into account operation at lower loss levels, variable crop and field conditions, availability of grain handling equipment, and differences in operating habits. Most operators could expect to attain average rates within this range, while some daily rates may approach the capacity test values.

The values from the average workrates should not be used to compare combines. The factors which affect workrates are too variable and cannot be duplicated for all combine tests.

TABLE 3. Average Workrates

Crop	Variety	Average Yield		Average Workrates			
		bu/ac	t/ha	ac/h	ha/h	bu/ac	t/h
Barley	Bonanza	56	3.0	8.6	3.6	482	10.5
Canola	Westar	30	1.7	8.9	3.6	267	6.1
Flax	Dufferin	21	1.3	7.0	2.8	147	3.7
Rye	Musketeer	25	1.6	11.7	4.7	293	7.5
Rye	Puma	25	1.6	10.9	4.4	273	6.9
Wheat	Katepawa	34	2.3	9.6	3.9	326	8.9
Wheat	Neepawa	33	2.2	12.5	5.1	413	11.2

Comparing Combine Capacities: The capacity of combines tested in different years or in different crop conditions can only be compared using the Machinery Institute reference combine. This is done by dividing the test combine capacity (MOG Feedrate at 3% loss), as shown in TABLE 2 by the corresponding capacity for the reference combine, found in TABLE 6. The resulting number (capacity ratio) can be used to compare capacities of combines in different years.

For example if a test combine has a capacity of 440 lb/min (12 t/h) MOG and the reference a capacity of 367 lb/min (10 t/h) MOG. The test combine capacity is 1.2 times the reference combine capacity [440/367 = 1.2 (12/10 = 1.2)]. Comparing this combine to a second combine which has 2 times the capacity of the reference, it can be seen that the second combine has 67% more capacity [(2 - 1.2)/1.2 x 100 = 67%].

A test combine can also be compared to the reference combine at losses other than 3%. The total loss curves of both machines are shown on the same graphs in FIGURES 7 to 11. Shaded bands around the curves represent 95% confidence belts. Where the bands overlap, very little difference in capacity could be noticed, where the bands do not overlap significant capacity differences existed.

Capacity Compared to Reference Combine: The capacity of the John Deere 8820 Titan II was much greater than that of the reference combine. At 3% loss the John Deere 8820 Titan II had about 2 times the capacity of the reference combine in both wheat and barley. FIGURES 7 to 11 compare the total loss curves of both combines.

These results indicate an increase in the relative overall capacity in wheat when compared to the results from the John Deere 8820 Titan tested in 1980. The main reason for increased capacity was due to lower unthreshed loss for this year. Unthreshed loss was affected by the difference in the thresh-ability of the crop and the higher cylinder speed, which could be tolerated.

QUALITY OF WORK

Picking: Windrows were picked using a John Deere 7-belt, three roller windrow pickup mounted on a 214 header platform.

The, pickup gage wheels were adjusted to allow the pickup teeth to just contact the ground. Pickup angle was either manually or automatically controlled from within the cab. Pickup speed was manually controlled with a flow control valve in the cab.

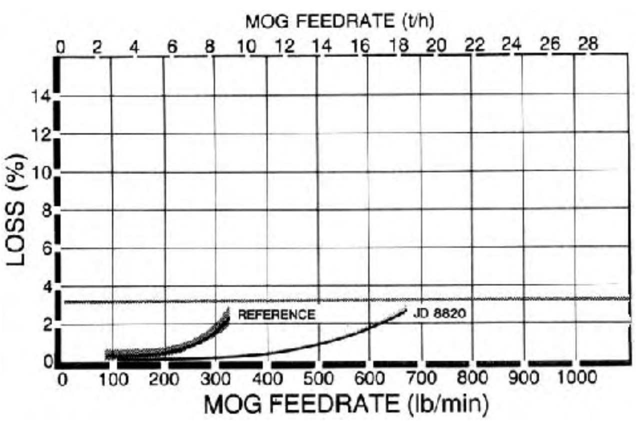

FIGURE 11. Total Grain Loss in Neepawa Wheat (Field E - Double Windrows).

Pickup performance was very good. The automatic pickup controller maintained the selected angle as ground contour varied. The controller greatly reduced operator adjustment.

Pickup draper speed was adequate for all crops encountered. Automatic speed control would have been very convenient.

In most crops, the pickup picked cleanly at speeds up to 5 mph (8 km/h). However, in thin windrows that had fallen through the stubble, pickup loss became significant at speeds over 3 mph (4.8 km/h).

The three roller design and fore-and-aft pickup adjustment provided smooth crop flow to the table auger in all conditions. The windguard kept crop from blowing off the pickup in windy conditions. The windguard was removed in canola to prevent excessive shelling. Adjustment to allow the windguard to be raised out of the way, without removal, would have been convenient.

Feeding: The table auger fed the crop to the slatted conveyor, which delivered it to the cylinder. Although the test machine is equipped with a variable speed feeder house, for the small grain crops it was run at its slowest speed as recommended by the manufacturer.

Feeding was excellent in all crops encountered. The floating table auger was very aggressive and there was very little restriction at the feeder opening. In bunchy crops, the table auger usually rode over the slug and fed it through. Plugging occurred only in very severe conditions.

Stone Protection: Hard objects, such as stones and roots, contacting the cylinder were driven into a stone trap in front of the cylinder. The stone trap had to be regularly cleaned out by hand to prevent dirt and grain from hardening in the pocket. This was a very dirty job.

Threshing: Threshing was accomplished by the 8 rasp bar cylinder and 13 bar concave.

The dual range cylinder drive was positive and did not slip. It provided adequate speed ranges for all crops encountered. The low range was especially useful as it provided extra torque to handle bunchy canola windrows at low cylinder speed.

The cylinder provided very good threshing in most crops. In easy-to-thresh crops, such as barley, threshing was nearly complete with very little kernel damage. Faster cylinder speeds were used in hard-to-thresh Neepawa wheat to maintain acceptable unthreshed loss. This caused slightly higher grain damage. In the tests, cylinder speeds of 1100 to 1150 rpm resulted in kernel damage of 2 to 4% in the clean grain. The cylinder speeds used in the various crops are given in TABLE 4.

Two rows of concave filler blanks were added to increase threshing in flax. However, this did not prevent immature unthreshed bolls from getting into the tank.

Very little wear could be seen on the hardened and chromed rasp bars after one season of use.

Separating: Grain separation occurred at the concave, beater grate, and straw walkers.

In most crops, maximum separation was achieved using as small a concave clearance, and as fast a cylinder speed as possible without causing excessive grain damage. The concave settings used in the various crops are shown in TABLE 4.

TABLE 4. Crop Settings

	Cyl-inder	Concave Clearance				Chaffer		Chaffer Extension		Sieve		Fan
Crop	rpm	in	mm	in	mm	in	mm	in	mm	in	mm	rpm
Barley	840	1/4	6	1/8	3	¾	19	3/4	19	1/4	6	790
Canola	600	3/4	19	3/8	10	5/8	15	5/8	15	1/8	3	700
Flax	900	1/4	6	1/16	2	1/2	13	3/4	19	1/16*	2	600
Fall Rye	900	1/4	6	1/8	3	1/2	13	3/4	19	3/16	5	825
Wheat	975	1/4	6	1/16	2	5/8	15	3/4	19	3/16	5	840

*Cleaning Sieve in Upper Position.

Although separation was good, grain loss over the straw walkers limited capacity in both barley and wheat. Increasing separation would have increased total capacity. Adding straw walker risers and extending the adjustable walker extension pans may slightly increase separation. To fully utilize the separating capacity of the John Deere 8820 Titan II, it is essential that it be operated in double or very wide single windrows which have the heads uniformly distributed across the windrow.

The separating capacity of the John Deere 8820 Titan II was slightly lower than that of the John Deere 8820 Titan tested in 1980. But, due to the large number of variables effecting separation, the exact cause for the decrease was not determined.

Cleaning: Chaff and debris were cleaned from the grain using a combination of sieving action and air. The air blast was supplied by a variable speed, paddle type fan with forward curved blades. The chaffer sieve and cleaning sieve moved in opposed motion. The tailings were returned to the cylinder for rethreshing.

The chaffer sieve and cleaning sieve on the John Deere 8820 Titan II were each 6 in (152 mm) longer than the 8820 Titan tested in 1980. The chaffer also had removable corner sections (FIGURE 12), which could be removed to retain grain, which might be lost when combining on side slopes.

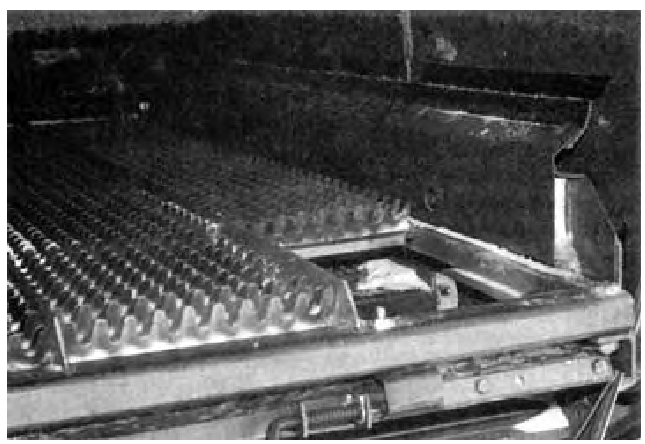

FIGURE 12. Chaffer Insert Removed.

The fan supplied an adequate air blast and the chaffer and sieve could be adjusted to suit most crops and conditions encountered. The shoe settings used for the various crops are given in TABLE 4. Very good shoe performance was obtained in most crops. Minimal loss and a clean grain sample could be maintained at reasonable feedrates. The actual shoe capacity was about 25 percent greater than that of the previously tested John Deere 8820 Titan. This increase in shoe capacity could not always be fully utilized but was beneficial in heavy shoe loading conditions.

In the test results, dockage of 4.5 to 6.5% appears high; however, the largest portion consisted of undersized kernels caused by hot dry weather during the crop filling stage.

In wheat and barley, the chaffer had to be set almost completely open to prevent grain loss. As the chaffer was closed, grain loss increased significantly. Operating the chaffer almost fully open to obtain optimum shoe capacity resulted in some straw spearing at the front of the chaffer sieve. To minimize straw spearing, it was necessary to use as high a fan speed as possible, without blowing out grain or causing excessive return tailings.

In dry canola, similar setting techniques were used. In tough canola crops, MOG break-up decreased causing higher losses. Thus, the large chaffer openings were not suitable. The shoe had to be reset and harvesting speeds reduced.

Shoe performance in flax was poor to fair. In dry conditions, the lower sieve blanketed with fine material, causing grain to spill into the fan housing. Raising the front of the sieve prevented grain from entering the fan housing but did not eliminate blanketing. Also, material built up behind the rubber deflectors on the front auger troughs causing straw to bridge and wrap (FIGURE 13).

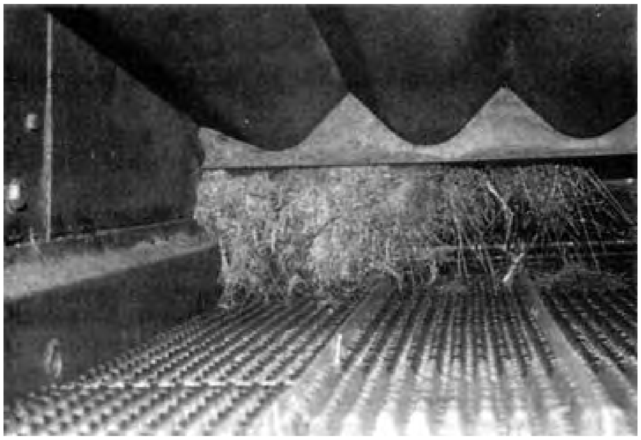

FIGURE 13. Straw Wrapping on Outer Shoe Supply Augers.

Green unthreshed flax bolls could not be removed from the clean grain even though the cleaning sieve was nearly closed and concave cover strips were added to improve threshing. In addition, grain loss was high over the outside chaffer edges when picking up a narrow windrow. However, this loss was greatly reduced by removing the corner sections of the chaffer extension.

Finally, flax seed leaked between the combine body and the left side of the shoe. Grain may have been able to get between these two components by first passing between the top front of the chaffer frame and the chutes from the shoe supply augers. Wear patterns on the metal seal between the supply augers and fan housing indicated a considerable amount of grain had been moving via this route. It is recommended that the manufacturer consider modifications to improve shoe sealing to prevent grain loss.

Clean Grain Handling: The clean grain elevator had adequate capacity for all the crops encountered.

The open grain tank on the John Deere 8820 Titan II filled evenly and completely and held approximately 215 Imp bu (7.8m^3) of dry wheat. The unloading auger had ample reach and clearance for unloading into trucks and grain trailers (FIGURE 14). The grain discharged in a compact stream and a full tank of dry wheat was unloaded in about 115 seconds. Unloading rates could be increased by opening the adjustable control gates.

FIGURE 14. Unloading.

Occasionally, the folding tank extensions blew down. If not detected, grain spilled over. In canola, the seed leaked through the grain tank screen. Therefore, the grain tank could only be partly filled unless additional screening or paint was used to block the holes. It is recommended that the manufacturer consider modifications to prevent small seeds from leaking through the screen.

Even with a flighting brush located near the end of the unloading auger, some grain was lost if the auger was swung back when full. Grain spillage was insignificant if the tank was allowed to completely empty and the auger to clean out.

The hydraulic swing was very convenient for unloading on-the-go and topping off loads.

Straw Spreading: The John Deer 8820 Titan II was equipped with a straw chopper with the extended tail plate and large deflectors. The straw chopper generally spread the straw evenly over about 30 ft (9 m) In optimum conditions, in double windrows. Spreads of up to 35 ft (10.7 m) were attained (FIGURE 15). Tail plate angle was critical with the optimum angle being 10 to 15 degrees up from the horizontal. Wind reduced spreading effectiveness.

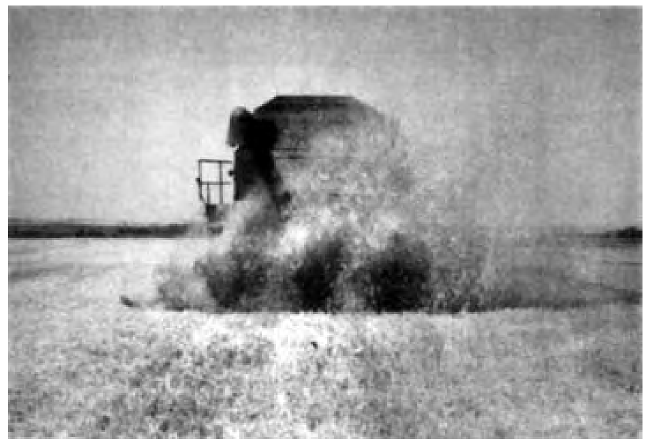

FIGURE 15. Straw Spreading.

The straw chopper had to be removed from the machine to permit dropping the straw. This was difficult as the straw chopper was very heavy and awkward to handle.

EASE OF OPERATION AND ADJUSTMENT

Operator Comfort: The John Deere 8820 Titan II was equipped with an operator's cab positioned ahead of the grain tank and to the left of the engine compartment. Operator comfort was very good. The cab was easily accessible and relatively quiet. Operator station sound level while harvesting was about 81 dBA.

Incoming air was effectively filtered while the fans pressurized the cab to reduce dust leaks. The heater and air conditioner worked well and provided comfortable cab temperatures in all conditions.

The seat and steering column were adjustable. The seat adjusted fore-and-aft independent of the vertical adjustment. This increased operator comfort and permitted better header visibility for shorter operators.

Visibility forward and to the left was very good. Visibility to the right was fair. Rear visibility was fair to the left but restricted directly behind. Rear view mirrors were provided. The convex mirror on the right was too far away and too small to be effective. The rear view mirror on the left provided a good view of traffic approaching from the rear but did not permit full view of the left side. An extra convex mirror on the left side and a larger one on the right would improve rear visibility. View of the incoming windrow was only partially blocked by the steering column (FIGURE 16). The grain in the tank could be viewed until the tank was 3/4 full. The operator had to leave the cab to determine when the tank was full. It is recommended that the manufacturer consider installing a full grain tank warning device.

Instruments: The instruments were located on a console to the right of the operator (FIGURE 17), while the loss monitor display was located on the pillar in the front left corner of the cab. Cylinder speed was indicated by a dial tachometer, while a digital readout selectively displayed engine speed, fan speed, ground speed, and front feeder shaft speed. Gauges indicated engine water temperature, engine oil pressure, battery voltage, and fuel level. In addition, warning lights indicated air filter restriction, park brake engagement, hydraulic and hydrostatic high oil temperatures, decrease in transmission oil pressure, plugged straw walkers, and reduced speed of major combine drives. Also located on the console was an engine hour meter. The cylinder tachometer, independent of the digital display, was very convenient. The digital readouts were very easy to read and were not affected by direct sunlight.

FIGURE 16. View of Incoming Windrow.

FIGURE 17. Instruments and Controls.

Controls: All the controls in the cab were color coded, distinctively shaped, and clearly marked for easy identification (FIGURE 17). Most were conveniently located and easy to operate. However, the park brake lever and header reverser control were located close together which created a pinch point for the operator's hand (FIGURE 18).

FIGURE 18. Pinch Point Between Park Brake Lever and Header Reverser.

The original pickup speed control was faulty and was replaced with an updated valve. The new control valve worked well, although it was moderately stiff to adjust. The automatic header height control was convenient and greatly reduced the adjustment required by the operator. This was especially beneficial while unloading on-the-go. The three preset pickup angles, which could be selected were adequate for most windrow conditions, while header response could be adjusted to suit terrain conditions.

Loss Monitor: Two grain loss sensor pads were located at the rear of the walkers and two at the rear of the chaffer sieve. The meter display was convenient to observe and easy to read. The operator could set the meter response and also select the readout for shoe loss, walker loss or both combined. The monitor detected mechanical shoe loss but not airborne shoe loss. Grain loss readings were meaningful only if compared to actual losses observed behind the combine. The monitor system effectively indicated changes in loss rates in wheat and barley, but was less representative in flax and canola.

Lighting: Lighting was very good for night time harvesting and transporting. The combine was equipped with seven front lights, a grain tank light, an unloading auger light, one tail light, and two warning/signal lights. A small colored light in the ceiling provided adequate lighting for most instruments and controls. All gauges except the hour meter had their own back lighting. The interior light provided extra light when required.

Handling: The John Deere 8820 Titan II was very maneuverable. The steering was smooth and responsive. The wheel brakes were positive and were required when picking around most windrow corners.

The transmission was easy to shift. The hydrostatic drive was responsive and made changing speeds and reversing quick and easy.

The combine was very stable in the field even with a full grain tank. However, normal caution was required when operating on hillsides. The combine transported well at speeds up to a maximum 15.5 mph (24.9 km/h).

Adjustment: Pickup speed, feeder speed, cylinder speed, and concave clearance could be easily adjusted from within the cab. Fan speed and sieve adjustments were located on the machine.

Table auger clearance and auger stripper adjustment were easily made to suit crop conditions and, once set, seldom had to be readjusted. Concave adjustment would be more convenient if the concave opening indicator was visible from inside the cab.

The fan speed adjustment, although not difficult to operate, would be more convenient if it was possible to observe the fan speed readout while adjusting. It is recommended that the manufacturer consider modifications to improve the convenience of fan speed adjustment. It was not possible for the operator to reach the sieve adjusting levers and still see through the top chaffer to determine the sieve openings. It is recommended that the manufacturer consider modifications to permit more convenient cleaning sieve adjustment.

Field Setting: The John Deere 8820 Titan II was easy to set for most crops and conditions encountered. Once initial settings were determined for the various crops, very little change was required when moving from field to field.

While setting, it was easy for the operator to check the clean grain sample and return tailings from the cab. Straw condition and unthreshed loss could be checked by shutting down quickly and checking the material on the straw walkers, thus eliminating the need of removing the straw chopper. Checking shoe loss was more difficult. The shaker pan over the rear axle diverted material from the centre of the shoe to either side. This made it difficult to determine loss patterns and to collect material coming off the shoe. It is recommended that the manufacturer consider modifications to carry the full width of shoe material over the rear axle to enable easier, more representative checking of shoe loss.

Unplugging: The power header reverser made unplugging the table auger and feeder quick and easy. Caution was required when reversing as crop material could lift the tin sheet between the pickup and table, allowing the auger fingers to damage it.

The cylinder, if not plugged severely, could be unplugged by lowering the concave, shifting the cylinder drive into low range, and powering the slug through. This, however, if not effective, could cause more severe plugging and/or breaking of the beater drive belt. To clear severe plugs, it was necessary to reverse the cylinder manually and remove the debris through the access doors. The upper cylinder access door was very difficult to remove once the cylinder was plugged. A cylinder slug wrench was not provided. It is recommended that the manufacturer consider supplying a cylinder slug wrench.

Machine Cleaning: Cleaning the John Deere 8820 Titan II for harvesting seed grain was time-consuming and laborious. The unloading auger sump retained a considerable amount of grain. Cleaning the sump was inconvenient. Cleaning the shoe delivery auger troughs required dropping the rear of the troughs and removing the front cleanout ports and flushing them with water. Removal of the chaffer and sieve required two people and was time-consuming. With the chaffer and sieve removed, the return tailings cross auger was accessible. The clean grain cross auger had clean-out doors on the bottom of the auger housing. The exterior of the combine was easy to clean.

Lubrication: The fuel tank inlet was located 6.5 ft (2 m) above the ground, making it easy to fuel from most gravity fuel tanks. The fuel tank also had a large inlet opening, which permitted the use of a large volume nozzles.

The combine had 46 pressure grease fittings. Six required greasing at 10 hours, an additional twenty-seven every 50 hours, six more at 200 hours, and another seven at 400 hours. The use of grease banks greatly improved the ease of lubrication. Daily lubrication was quick and easy because of the few number of lubrication points. Engine and hydraulic oil levels required regular checking. Changing engine oil and filters was not difficult.

Maintenance: Routine maintenance was easy to perform. The rotary radiator screen could be easily swung out of the way to provide access to the front of the radiator for inspection or cleaning.

The outer dry element air filter had to be cleaned or changed when indicated by the restriction warning. It was accessible through the grain tank.

The tension on most chains and belts was maintained through spring-loaded tighteners, and required very little adjustment. Slip clutches protected the table auger, feeder conveyor, straw walkers, shoe supply augers, and the tailings return elevator.

The header platform could be easily removed by one person in approximately five minutes. Complete removal of the header platform and feeder house assembly was time-consuming Jack stands were not provided to support the complete assembly when disengaging it from the machine.

The return plugged once in high moisture wheat, which may have been due to over greasing the slip clutch. The operator had to be careful not to over grease any slip clutches. Excessive grease works its way into the jaw faces and drastically reduces their effectiveness.

Adjustments were provided for levelling and proportioning the concave to the cylinder. These were difficult to reach, making adjustments very inconvenient.

ENGINE AND FUEL CONSUMPTION

The John Deere diesel engine started easily and ran well. The engine had adequate power for all crops and conditions encountered.

Average fuel consumption based on separator hours was about 6.5 gal/h (29.5 L/h). Oil consumption was insignificant.

OPERATOR SAFETY

The operator's manual emphasized operator safety.

The John Deere 8820 Titan II had warning decals indicating most dangerous areas. Moving parts were well shielded. Most shields were hinged or were easily removed and replaced. A header lock was provided and should always be used when working near the header or when the combine is left unattended. The combine could be safely adjusted if the recommended procedures were used. However, the operator had to position himself in front of the rear tire when adjusting the cleaning fan speed (FIGURE 19). This was potentially hazardous, especially if adjusting on-the-go. It is recommended that the manufacturer consider modifications to eliminate the potential hazard associated with adjusting the fan speed on-the-go.

The combine was equipped with a slow moving vehicle sign, warning lights, tail light, signal lights, and rear view mirrors to aid in safe road transport.

A fire extinguisher (Class ABC) should be carried on the combine at all times.

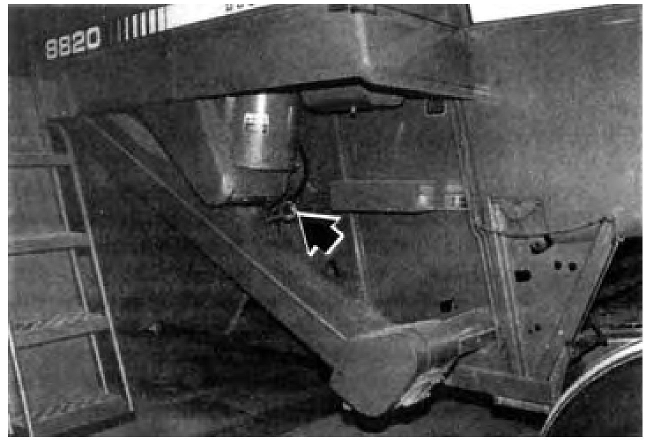

FIGURE 19. Fan Speed Adjustment.

OPERATOR'S MANUAL

The operator's manual was clearly written and well illustrated. It contained much useful information on safe operation, controls, adjustments, crop setting, servicing, troubleshooting, and machine specifications.

MECHANICAL HISTORY

TABLE 5 outlines the mechanical history of the John Deer 8820 Titan II during the 119 hours of field operation while harvesting about 1259 ac (510 ha). The intent of the test was functional performance evaluation. Extended durability testing was not conducted.

TABLE 5. Mechanical History

Item	Operating Hours	Field Area ac	Field Area (ha)
Drives:			
-The beater drive belt broke and was replaced at	19, 22	225, 256	(91, 104)
-The cylinder variable speed drive belt broke and was replaced at	21, 22	248, 256	(100, 104)
Miscellaneous:			
-The variable speed pickup control valve stuck and the control knob came loose	Throughout the season		
-The cylinder front access door was bent	Throughout the season		
-The automatic header height control quit working at	110	1150	(465)
and was repaired at	End of season		

Cylinder Drive Belts: The cylinder variable speed drive belt "turned over" twice in bunchy rye windrows, causing the cylinder to plug. The belts were damaged and had to be replaced. The only possible cause determined was the lack of grease in the torque sensing hub. Apparently it was not adequately packed during assembly and regular servicing did not provide sufficient lubrication. Once properly lubricated no further problems occurred. It is recommended that the manufacturer consider modifications to ensure that the torque sensing hubs are adequately lubricated before shipment.

Beater Drive Belt: The beater drive belt broke while power unplugging, as wads of material were fed to the beater before it was up to speed. If power unplugging is encouraged, it is recommended that the manufacturer consider modifications to prevent beater drive belt failure when power unplugging.

Pickup Speed Control: The control valve seized when the oil temperature increased. Trying to adjust the valve when it was stuck caused the linkage to slip and the entire adjusting knob and stem to come off the valve. An updated valve and stem assembly were installed near the end of the season. No further problems were encountered.

Cylinder Access Door: The cylinder access door bent when the cylinder was plugged. Once it was bent, the correct gap of 1/4 in (6 mm) could not be obtained. Straightening the door was only useful until the cylinder plugged again. No problems in feeding or threshing could be noticed because of the bent door.

APPENDIX I
SPECIFICATIONS

MAKE:	John Deere Self-Propelled Combine
MODEL:	8820 Titan II
SERIAL NUMBER:	Header - H00214X600234 Body - H08820X612601 Engine - RG6466A272105
MANUFACTURER:	John Deere Harvester Works East Moline, Illinois 61244 U.S.A.
WINDROW PICKUP:	
-- make and model	John Deere 214
-- type	belt
-- pickup width	13 ft (4 m)
-- number of belts	7
-- type of teeth	plastic
-- number of rollers	3
-- height control	castor gauge wheels
-- speed control	hydrostatic
-- speed range	0 to 8.1 ft/s (0 to 2.5 m/s)
HEADER:	
-- type	centre feed
-- width	
- table	13 ft (4 m)
- feeder house	65.3 in (1659 mm)
-- auger diameter	24 in (610 mm)
-- feed conveyor	4 roller chains with undershot slatted conveyor
-- conveyor speed	7.5 to 11.4 ft/s (2.3 to 3.5 m/s)
-- range of picking height	-8.25 to 47.25 in (-210 to 1200 mm)
-- number of lift cylinders	2
-- raising time	5 s
-- lowering time	adjustable
-- options	200 series cutting platform, 50 A series row crop header, 40 series corn head, 218 draper head, automatic header height control, accumulator
STONE PROTECTION:	
-- type	sump
-- cleaning	manually opened and reset
CYLINDER:	
-- type	rasp bar, hardened and chromed
-- number of bars	8
-- diameter	22 in (560 mm)
-- width	65 in (1851 mm)
-- drive	dual range, hydraulically controlled variable pitch torque-sensing belt drive
-- speed range	
- low	350 to 700 rpm
- high	600 to 1230 rpm
-- options	slow speed drive, mud shields, filler plates, spike tooth
BEATER:	
-- type	drum with 6 triangular bats
-- diameter	13.5 in (343 mm)
-- speed	150% of cylinder speed
-- grate	adjustable bar
-- options	adjustable finger bar
CONCAVE:	
-- type	bar and wire
-- number of parallel bars	13
-- configuration	12 intervals with 0.25 in (6.3 mm) wires and 0.75 in (19 mm) spaces
-- wrap	108 degrees
-- total area	1320 in^2 (0.85 m^2)
-- open area	730 in^2 (0.47 m^2) (55%)
-- beater grate	
- total area	490 in^2 (0.32 m^2)
- open area	318.5 in^2 (0.21 m^2)
-- grain delivery to shoe	augers
-- options	cover strips, stone trap cover, spiked tooth concave
STRAW WALKERS:	
-- type	formed metal, rectangular openings
-- number	6
-- length	150 in (3810 mm)
-- walker housing width	65.75 in (1670 mm)
-- separating area	9860 in^2 (6.36 m^2)
-- crank throw (radius)	3 in (76 mm)
-- speed	157 rpm
-- grain delivery to shoe	augers
-- straw curtains	2, adjustable
-- options	lip type, risers
SHOE:	
-- type	opposed action
-- speed	328 rpm
-- chaffer sieve	1.1 in regular tooth adjustable lip, 4309 in^2 (2.78 m^2) including chaffer extension, 3519 in^2 (2.27 m^2) less chaffer extension
-- chaffer sieve extension	adjustable lip with nonadjustable removeable inserts at rear corners 790 in^2 (0.51 m^2)
-- clean grain sieve	regular tooth adjustable lip, 3390 in^2 (2.19 m^2)
-- options	regular tooth 1.6 in (41 mm) space, deep tooth 1.8 in (41 mm) space, deep tooth cleaning sieve
CLEANING FAN:	
-- type	4 blade undershot
-- diameter	19.9 in (505 mm)
-- width	64.25 in (1632 mm)
-- drive	variable speed belt
-- speed range	370 to 1100 rpm
-- options	fan bottom protection shields
ELEVATORS:	
-- type	roller chain with rubber paddles
-- clean grain (top drive)	3.25 x 8 in (83 x 203 mm)
-- tailings (bottom drive)	3.25 x 6 in(83 x 152 mm)
-- options	perforated parts, steel paddles, bucket elevator
GRAIN TANK:	
-- capacity	215 Imp bu (7.82 m^3)
-- unloading time	115 s
-- unloading rate	1.87 bu/s (0.068 m^3/s)
-- unloading auger diameter	12 in (305 mm)
-- unloading auger length	17 ft (5.2 m)
-- options	20 ft (6.1 m) auger
STRAW CHOPPER:	
-- type	hammer and adjustable knife
-- width	65 in (1650 mm)
-- speed	2350 rpm
-- options	spreaders, corn kit
ENGINE:	
-- make	John Deere
-- model	6466AH-02
-- type	4 stroke turbocharged diesel
-- number of cylinders	6
-- displacement	466 in^3 (7.64 L)
-- governed speed (full throttle)	2340 rpm
-- manufacturers rating	225 hp (168 kW) at 2200 rpm
-- fuel tank capacity	83 Imp gal (380 L)
-- options	rotary screen trash shield
CLUTCHES:	
-- header	electro-magnet
-- separator	mechanical v-belt tightener
-- unloading auger	mechanical v-belt tightener
NUMBER OF CHAIN DRIVES:	9
NUMBER OF BELT DRIVES:	19
NUMBER OF GEARBOXES:	5
LUBRICATION POINTS:	
-- 10 h	6
-- 50 h	27
-- 200 h	6
-- 400 h	7
TIRES:	
-- front	24.5 - 32 R1, 12-ply
-- rear	11.25 - 24, 8-ply
TRACTION DRIVE:	
-- type	hydrostatic
-- speed ranges	
- 1st gear	0-1.6 mph (0-2.6 km/h)
- 2nd gear	0-3.6 mph (0-5.8 km/h)
- 3rd gear	0-6.5 mph (0-10.5 km/h)
- 4th gear	0-15.5 mph (0-24.1 km/h)
-- options	front wheel spacers, tracks
-- rear	powered rear axle, heavy duty axle
OVERALL DIMENSIONS:	
-- wheel treat (front)	12.5 ft (3.8 m)
-- wheel tread (rear)	11.2 ft (3.4 m) (adjustable)
-- wheel base	12.6 ft (3.8 m)
-- transport height	12.6 ft (3.8 m)
-- transport length	36.7 ft (11.2 m)
-- transport width	16.4 ft (5.0 m)
-- field height	13.4 ft (4.1 m) (unloader retracted)
-- field length	36.7 ft (11.2 m) (unloader retracted)
-- field width	16.4 ft (50 m) (unloader retracted)
-- unloader discharge height	12.7 ft (3.9 m)
-- unloader reach	11.7 ft (3.6 m)
-- unloader clearance	12.1 ft (3.7 m)
WEIGHT (EMPTY GRAIN TANK):	
-- right front wheel	9887 lb (4485 kg)
-- left front wheel	10615 lb (4815 kg)
-- right rear wheel	2490 lb (1130 kg)
-- left rear wheel	2490 lb (1130 kg)
TOTAL	25482 lb (11560 kg)

APPENDIX II
MACHINERY INSTITUTE REFERENCE COMBINE CAPACITY RESULTS

TABLE 6 and FIGURES 20 and 21 present the capacity results for the Machinery Institute reference combine in barley and wheat crops harvested from 1980 to 1984.

FIGURE 20 shows capacity differences in six-row Bonanza barley for 1981, 1982, and 1983, and two-row Hector barley for 1980. The 1984 Bonanza barley crops shown in TABLE 6 had slightly above average straw yield, grain yield, and straw moisture with average grain moisture

FIGURE 21 shows capacity differences in Neepawa wheat for the five years. In 1984 the wheat crop had slightly greater than average straw yield, slightly below average grain yield, and average straw and grain moisture contents.

Results show that the reference combine is important in determining the effect of crop variables and in comparing capacity results of combines evaluated in different growing seasons.

TABLE 6. Capacity of the Machinery Institute Reference Combine at a Total Grain Loss of 3% Yield

	Crop Conditions									Capacity Results						
			Width of Cut		Crop Yield		Grain Moisture		MOG/G	MOG Feedrate		Grain Feedrate		Ground Speed		
Year	Crop	Variety	ft	m	bu/ac	t/ha	Straw %	Grain %	Ratio	lb/min	t/h	bu/h	t/h	mph	km/h	Loss Curve
1984	Barley	Bonanza[1]	42	12.8	68.0	3.7	18.5	12.9	0.74	275	7.5	464	10.1	1.3	2.1	Fig. 20
	Barley	Bonanza	24	7.3	85.0	4.6	12.0	12.1	0.62	213	5.8	429	9.4	1.7	2.7	
	Wheat	Neepawa[1]	44	13.4	42.0	2.8	6.7	11.8	1.47	308	8.4	209	5.7	0.9	1.4	Fig. 21
	Wheat	Neepawa[1]	42	12.8	41.0	2.8	8.5	10.3	1.17	356	9.7	304	8.3	1.5	2.4	
	Wheat	Neepawa[1]	42	12.8	23.0	1.6	7.2	12.5	0.99	345	9.4	348	9.5	3.0	4.8	
1983	Barley	Bonanza	28	8.5	71.9	3.3	11.7	13.2	0.86	226	6.2	263	7.2	1.6	2.6	
	Barley	Bonanza	24	7.4	72.5	3.6	6.7	10.7	0.85	313	8.5	368	10.0	2.4	3.8	Fig. 20
	Wheat	Neepawa	27	8.2	40.3	2.9	5.1	10.0	1.01	340	9.3	337	9.2	2.6	4.2	Fig. Fig. 20
	Wheat	Columbus	41	12.5	36.7	2.7	7.9	11.3	1.36	425	11.6	313	8.5	1.6	2.6	Fig. 19
1982	Barley(A)	Bonanza	28	8.5	75	4.09	22.3	10.6	0.79	205	5.6	325	7.1	1.3	2.0	
	Barley(B)	Bonanza[2]	50	15.2	55	2.99	9.3	12.4	0.68	227	6.2	417	9.1	1.3	2.0	Fig. 20
	Wheat(C)	Neepawa[1]	40	12.2	40	2.73	11.1	13.6	0.68	414	11.3	609	16.6	3.1	5.0	
	Wheat(D)	Neepawa[1]	40	12.2	41	2.79	10.3	14.3	0.81	356	9.7	440	12.0	2.2	3.5	
	Wheat(E)	Neepawa	25	7.6	47	3.21	6.0	7.9	0.89	326	8.9	367	10.0	2.6	4.1	
	Wheat(F)	Neepawa	25	7.6	53	3.59	6.6	11.0	0.88	322	8.8	367	10.0	2.3	3.7	Fig. 21
1981	Barley	Bonanza	25	7.6	62	3.33	7.2	12.6	0.67	205	5.6	385	8.4	2.2	3.5	Fig. 20
	Barley	Klages	25	7.6	53	2.86	7.1	12.0	0.68	220	6.0	403	8.8	2.6	4.2	
	Wheat	Manitou	25	7.6	51	3.46	6.3	13.8	0.96	312	8.5	326	8.9	2.2	3.5	
	Wheat	Neepawa	27	8.2	55	3.69	6.4	11.9	0.85	348	9.5	410	11.2	2.3	3.7	Fig. 21
	Wheat	Neepawa	24	7.4	49	3.29	6.2	13.7	0.93	337	9.2	363	9.9	2.6	4.1	
1980	Barley	Hector	20	6.1	65	3.48	13.8	14.5	0.69	202	5.5	367	8.0	2.4	3.8	Fig. 20
	Barley	Hector	20	6.1	59	3.16	13.4	14.4	0.68	213	5.8	390	8.5	2.8	4.4	
	Wheat	Neepawa[1]	40	12.2	43	2.87	7.2	13.2	0.88	345	9.4	389	10.6	1.9	3.0	
	Wheat	Neepawa	20	6.1	46	3.12	6.0	11.4	0.98	370	10.1	378	10.3	3.4	5.4	Fig. 21
	Wheat	Neepawa[1]	40	12.2	46	3.09	6.2	12.2	1.02	374	10.2	367	10.0	1.7	2.7	
	Wheat	Neepawa	20	6.1	45	3.00	4.4	10.8	0.91	378	10.3	414	11.3	3.9	6.2	

[1]side-by-side double windrow
[2]double windrows lapped by 1/3

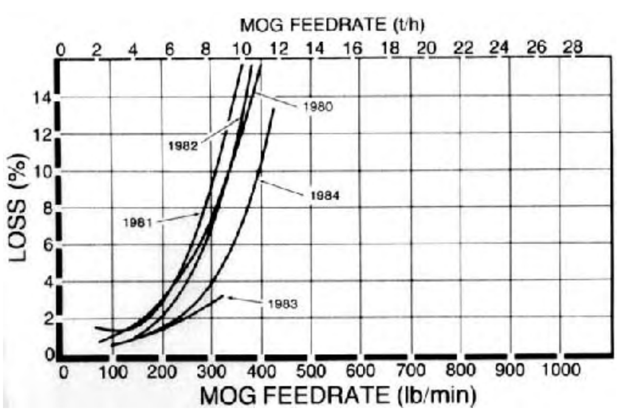

FIGURE 20. Total Grain Loss for the Reference Combine in Bonanza Barley.

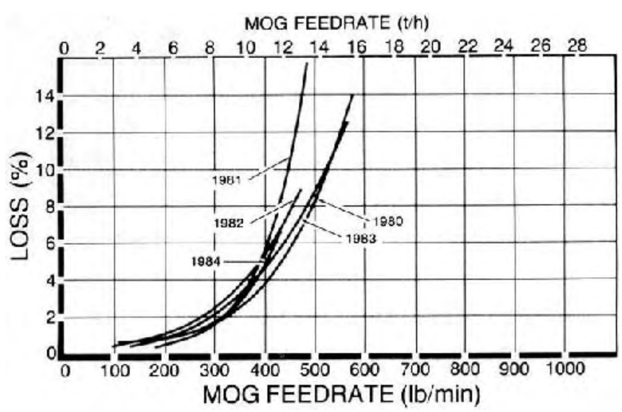

FIGURE 21. Total Grain Loss for the Reference Combine in Neepawa Wheat.

APPENDIX III
REGRESSION EQUATIONS FOR CAPACITY RESULTS

Regression equations for the capacity results shown in FIGURES 2 to 6 are presented in TABLE 7. In the regressions, U = unthreshed loss in percent of yield S = shoe loss in percent of yield, W = walker loss in percent of yield, F = the MOG feedrate in lb/min, while $\ln$ is the natural logarithm. Sample size refers to the number of loss collections. Limits of the regressions may be obtained from FIGURES 2 to 6 while crop conditions are presented in TABLE 2.

TABLE 7. Regression Equations

Crop - Variety	Figure Number	Regression Equations	Simple Correlation Coefficient	Variance Ratio	Sample Size
Barley - Bonanza	2	$U = 0.88 + 1.32 \times 10^{-6}F^2$ $\ln S = -3.68 + 5.41 \times 10^{-3}F$ $W = 0.07 + 1.58 \times 10^{-11}F^4$	0.82 0.49 0.95	32.26[2] 6.75[1] 120.96[2]	9
Barley - Bonanza	3	$U = -0.03 + 3.76 \times 10^{-6}F^2$ $\ln S = -2.60 + 3.26 \times 10^{-3}F$ $W = 0.06 + 9.77 \times 10^{-11}F^4$	0.96 0.51 0.96	153.92[2] 6.15[1] 184.16[2]	8
Wheat - Columbus	4	$U = 0.02 + 3.63 \times 10^{-15}F^5$ $\ln S = -6.12 + 8.12 \times 10^{-3}F$ $\ln W = -25.02 + 3.99 \ln F$	0.88 0.94 0.94	53.44[2] 103.63[2] 101.55[2]	9
Wheat - Neepawa	5	$U = 0.20 + 1.03 \times 10^{-12}F^4$ $S = 0.04 + 1.00 \times 10^{-4}F^1$ $W = -0.07 + 7.73 \times 10^{-12} F^4$	0.95 0.43 0.99	103.15[2] 4.54 1680.00[2]	8
Wheat - Neepawa	6	$U = 0.08 + 1.34 \times 10^{-9}F^4$ $S = 0.002 + 9.02 \times 10^{-5}F^1$ $W = -0.05 + 1.06 \times 10^{-11} F^4$	0.96 0.57 0.98	182.83[2] 9.52[1] 356.08[2]	9

[1]Significant at $P < 0.05$
[2]Significant at $P < 0.01$

APPENDIX IV

Machine Ratings

The following rating scale is used in Machinery Institute Reports:

excellent	fair
very good	poor
good	unsatisfactory

SUMMARY CHART
JOHN DEERE 8820 TITAN II SELF-PROPELLED COMBINE

RETAIL PRICE $160,911.00 (March, 1985, f.o.b. Humboldt, Sask.)	
CAPACITY	
Compared to Reference	
Combine -- barley	2 x reference at 3% total loss
-- wheat	2 x reference at 3% total loss
MOG Feedrates	
-- barley - Bonanza	583 lb/min (15.9 t/h) at 3% total loss, FIGURE 2
- Bonanza	385 lb/min (10.5 t/h) at 3% total loss, FIGURE 3
-- wheat - Neepawa	641 lb/min (17.5 t/h) at 3% total loss, FIGURE 4
- Neepawa	748 lb/min (20.4 t/h) at 3% total loss, FIGURE 5
- Neepawa	689 lb/min (18.8 t/h) at 3% total loss, FIGURE 6
QUALITY OF WORK	
Picking	**Very Good;** automatic header height control is convenient
Feeding	**Excellent;** very aggressive in all crops
Stone Protection	**Good;** dirty to clean out
Threshing	**Very Good;** chromed rasp bars show little wear
Separating	**Good;** straw walker loss limited capacity
Cleaning	**Very Good;** poor to fair in flax
Grain Handling	**Very Good;** full grain tank warning would be useful; grain tank screen leaked small seeds
Straw Spreading	**Very Good;** uniformly over 30 ft (9.1 m)
EASE OF OPERATING AND ADJUSTMENT	
Comfort	**Very Good**; seat had good adjustments, visibility was good
Instruments	**Very Good;** easy to read
Controls	**Very Good;** color coded for quick identification
Loss Monitor	**Good;** easy to read, less representative in flax and rapeseed than in wheat and barley
Lighting	**Very Good;** exterior and interior
Handling	**Good;** brakes responsive, steering smooth, slow transport speed Adjustment **Good;** cleaning sieve difficult to see while adjusting
Setting	**Good;** difficult to get representative shoe sample
Unplugging	**Good;** power header reverser, no cylinder slug wrench was provided Cleaning **Fair;** many auger troughs to clean, time-consuming
Lubrication	**Very Good;** grease banks are handy, few daily lubrication points Maintenance **Good;** wide spaced front wheels allow good access
ENGINE AND FUEL CONSUMPTION	
Engine	**Good;** adequate power, started well
Fuel Consumption	6.5 gal/h (29.5 L/h), average for season
OPERATOR SAFETY	Well shielded, but accessible
OPERATOR'S MANUAL	**Very Good;** well written
MECHANICAL HISTORY	Cylinder torque sensing hubs not adequately lubricated

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