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Evaluation Report 313

Massey Ferguson 860 Self-Propelled Combine

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

MASSEY FERGUSON 860 SELF-PROPELLED COMBINE

MANUFACTURER
Massey Ferguson Industries Ltd.
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Toronto, Ontario
M6K 1E3

DISTRIBUTOR
Massey Ferguson Industries Ltd.
P.O. Box 1340, Station T
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RETAIL PRICE
$120,670.00 (April, 1983, f.o.b. Humboldt, with a 13 ft (3.9 m) header, 10 ft (3.2 m) Victory pickup, 24.5 x 32 R1 drive tires, 14L x 16.1 steering tires, Perkins AV8.540 diesel engine, hydrostatic trans-mission drive, straw chopper, straw walker risers, small seed fan kit, wide space concave, paddle type feed conveyor, adjustable rear axle, heater and radio).

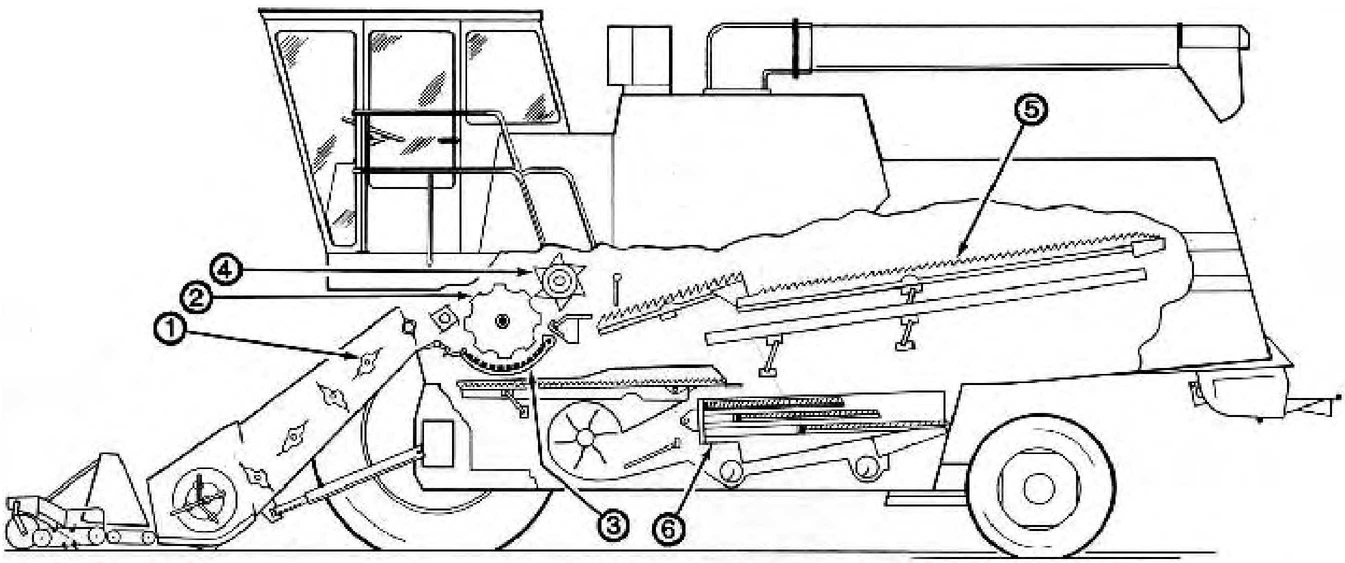

FIGURE 1. Massey Ferguson 860: (1) Paddle Feeder, (2) Cylinder, (3) Concave, (4) Back Beater, (5) Straw Walker, (6) Cleaning Shoe.

SUMMARY AND CONCLUSIONS

Functional Performance: Functional performance of the Massey Ferguson 860 was very good in dry and tough cereal grain crops and in rapeseed.

Capacity: The MOG Feedrate* at 3% total grain loss varied from 312 lb/min (8.5 t/h) in 56 bu/ac (3.0 t/ha) Bonanza barley to 502 lb/min (13.7 t/h) in 46 bu/ac (3.1 t/ha) Neepawa wheat.

The capacity of the Massey Ferguson 860 compared to that of the Machinery Institute reference combine at 3% total grain loss was about 1.4 times greater in barley and about 1.45 times greater in wheat.

Grain loss limited combine capacity in all crops encountered. Grain loss due to incomplete threshing was low in barley but was signi cant in the hard-to-thresh wheat crops. A reduction in unthreshed loss would have increased combine capacity in wheat. Grain loss over the straw walkers limited capacity in most barley crops, but was much lower in wheat crops. Shoe loss occasionally became signi cant in all crops due to material build-up and overloading on the left side of the shoe.

Ease of Operation: The Massey Ferguson 860 was very convenient to operate. Forward and side visibility was good. Rear visibility to the left was good, but was restricted to the use of the rear view mirror on the right. The steering was smooth and easy. The wheel brakes were positive and aided in turning. Combine maneuverability and handling were very good in the eld and good while transporting. Lighting for harvesting at night was good. Most instruments and controls were conveniently located, easy to use, and responsive. Some controls interfered with each other. The cab was relatively dust free. The heater and air conditioner provided comfortable cab temperatures in all conditions. Operator station sound level was about 89 dBA. The noise level did not increase signi cantly while harvesting.

The engine started fairly easy and ran well. It had ample power for harvesting in all conditions encountered. The average fuel consumption for the test season was about 4.5 gal/h (22.4 L/h).

The pickup picked well in most crops and fed the material under the table auger. The table auger plugged occasionally in bunchy windrows but could be easily cleared. The feeder paddles were fairly aggressive, but plugged occasionally in bunchy windrows. Unplugging the feeder paddles was dif cult. The cylinder was very aggressive and seldom plugged. The cylinder, if not plugged severely, could be power unplugged. The stone trap effectively stopped most stones and roots from entering the cylinder. Emptying the stone trap was easy and convenient. The front grain pan occasionally plugged with dirt and awns and was inconvenient to clean. Occasionally the shoe plugged on the left side but was easy to clean.

The straw chopper cut and spread straw over about 15 ft (4.6 m). The ease of disengaging the straw chopper to permit windrowing the straw was good. The unloading auger was easy to position and could be varied for convenient unloading. It had ample reach and clearance for unloading into “most trucks and trailers. The scattered discharge made it dif cult to unload on-the-go,

Ease of lubrication and service was good. Accessibility was poor for cleaning and good for repair,

Ease of Adjusting: Ease of adjusting the components on the Massey Ferguson 860 was very good. Cylinder speed, pickup speed and concave clearance was adjustable from within the cab and could be varied on-the-go. Fan speed, wind board position and shoe setting had to be made on the machine.

Ease of setting the machine to suit crop conditions was fair. The return tailings could not be easily sampled. The grain sample was dif cult to check until the tank was half full. The cascade

**MOG Feedrate (Material-Other-than-Grain Feedrate) is the mass of straw and chaff passing through the combine per unit time.*

shoe required considerable experimenting to become familiar with the affects of the numerous adjustments available.

Operator Safety: The Massey Ferguson 860 was safe to operate if normal safety precautions were taken.

Operator Manual: The operator manual was well illustrated, clearly written and provided much useful information.

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

RECOMMENDATIONS

It is recommended that the manufacturer consider:

1. Improving rear visibility to the right.
2. Modifications to prevent interference between the pickup speed control knob and the concave adjusting lever.
3. Modifications to prevent interference between the unloading auger engaging lever and the parking brake lever.
4. Modifications to prevent material build-up on the concave adjusting linkages.
5. Improving visibility of the grain level from the operator's seat.
6. Modifying the deflector shield on the unloading auger spout to control the grain discharge.
7. Modifications to provide a more uniform spread pattern from the straw chopper.
8. Supplying a safe convenient apparatus to permit sampling the return tailings.
9. Modifications to improve air distribution to the cleaning shoe.
10. Providing a hinged shield for the table auger drive chain.
11. Relocating the fan speed control crank to permit safe adjusting while harvesting.
12. Including all the recommended initial crop settings in one chart.
13. Revising the suggested cylinder, concave, and fan settings in the operator manual for rapeseed.
14. Providing as standard equipment a protective screen for the hydrostatic transmission heat exchanger.

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Project Technologist: W. A. Beckett

THE MANUFACTURER STATES THAT:

With regard to recommendation number:

1. Massey Ferguson has recognized this problem and has installed larger mirrors for 1983.
2. In 1983 production, we have relocated the pickup speed control knob to the top of the console.
3. This will be investigated.
4. This will be investigated.
5. Current models have perforated extensions, which will improve visibility.
6. 1983 production Massey Ferguson 860's will have the wrap around deflector as standard equipment.
7. This is being investigated.
8. Massey Ferguson is investigating a tong term improvement.
9. In 1983, Massey Ferguson 860's will have fanning mill dividers that improve air distribution to the shoe. A deflector has also been added to a walker to distribute rethresher material evenly across the walker pan.
10. Massey Ferguson 9000 series header (new for 1983) will feature a hinged shield.
11. This is being investigated.
12. This is being investigated for 1984.
13. The settings for rapeseed have been changed in the 1983 operator manual,
14. The screen is standard for 1983.

GENERAL DESCRIPTION

The Massey Ferguson 860 is a self-propelled combine with a trans-verse-mounted, tangential threshing cylinder, concave, straw walkers, and cleaning shoe. Threshing and initial separation occur at the cylinder and concave while the straw walkers complete final separation of grain from straw. Grain is cleaned at the shoe with tailings delivered to a rethresher.

The test machine was equipped with a 182 hp (136 kW) eight cylinder Perkins diesel engine, a 13 ft (3.9 m) header, a 10 ft (3.2 m) Victory pickup, straw chopper and other optional equipment listed on page 2.

The Massey Ferguson 860 has a pressurized operator's cab, power steering, hydraulic wheel brakes and hydrostatic traction drive. The separator and unloading auger drives are manually engaged through over-center belt tighteners while the header is engaged with an electromagnetic clutch. Unloading auger swing is hydraulically operated and the header height is electro-hydraulically controlled. Concave clearance, pickup speed and cylinder speed are adjusted from within the cab. Fan speed and shoe settings are adjusted on the machine. There is no provision to quickly and safely sample return tailings. Most component speeds and harvest functions are monitored in the cab.

Detailed specifications are given in APPENDIX I.

SCOPE OF TEST

The Massey Ferguson 860 was operated for 153 hours while harvesting about 1450 ac (587 ha) of various crops. The crops and conditions are shown in TABLES 1 and 2. It was evaluated for ease of operation, ease of adjustment, rate of work, grain loss characteristics, operator safety, and suitability of the operator's manual. Throughout the tests, comparisons were made to the Machinery Institute reference combine.

TABLE 1. Operating Conditions

Crop	Variety	Average Yield		Swath Width		Hours	Field Area	
		bu/ac	t/ha	ft	m		ac	ha
Barley	Bonanza	50	2.7	25, 28, 50	7.6, 8.5, 15.2	23.0	185	23.0
Barley	Elrose	52	2.6	18, 50	5.5, 15.2	7.5	62	7.5
Rapeseed	Regent	27	1.5	20, 24, 25	6.1, 7.3, 7.6	34.0	279	34.0
Rye	Puma	33	2.1	20, 24, 40	6.1, 7.3, 12.2	51.0	534	51.0
Wheat	Benito	30	2.0	50	15.2	6.0	57	23.0
Wheat	Neepawa	33	2.2	18, 24, 40, 50	5.5, 7.3, 12.2, 15.2	27.0	284	115.0
Wheat	Park	25	1.7	24	7.3	2.5	27	2.5
Wheat	Sinton	42	2.8	15, 28	4.6, 8.5	2.0	22	9.0
Total						153.0	1450	587.0

TABLE 2. Operation in Stony Fields

Field Condition	Hours	Field Area (ha)	
		ac	ha
Stone Free	66	595	241
Occasional Stones	53	487	197
Moderately Stony	34	368	149
Total	153	1450	587

RESULTS AND DISCUSSION

EASE OF OPERATION

Operator Location: The Massey Ferguson 860 combine was equipped with an operator's cab positioned ahead of the grain tank and left of the center of the combine body. Forward and side visibility was very good. Rear visibility was good on the left but was restricted on the right. The rear view mirror on the right side was too small and too far away to be useful. It is recommended that the manufacturer consider improving rear visibility to the right. For most operators, view of the incoming windrow was very good (FIGURE 2). The grain level was very difficult to view from the operator's cab.

The seat and steering column were adjustable, providing a comfortable combination for most operators. Incoming air was effectively filtered while the fans pressurized the cab to reduce dust leaks. The heater and air conditioner provided comfortable cab temperatures. Operator station sound level was about 89 dBA and did not increase significantly while harvesting at capacity. The high sound level was uncomfortable and bordered on causing operator hearing damage.[2]

Controls: The controls for the Massey Ferguson 860 are shown in FIGURES 3 and 4. Most controls were conveniently located, clearly identified and easy to operate. The pickup speed control

[2]The noise tolerance limit before hearing damage will occur as expressed by the "Walsh Healy Act", is a duration of eight hours/day at a sound level of 90 dBA.

knob was responsive, but dif cult to reach if the concave adjusting lever was positioned from numbers 1 to 6. The parking brake lever interfered with the unloading auger lever if both were engaged. It is recommended that the manufacturer consider modi cations to prevent interference between the pickup speed control knob and the concave adjusting lever, and also between the unloading auger engaging lever and the parking brake lever.

FIGURE 2. View of Incoming Windrow.

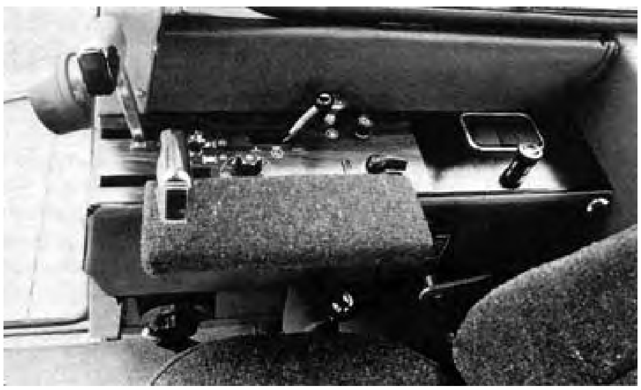

FIGURE 3. Control Console to the Right of the Operator.

FIGURE 4. Controls to the Left of the Operator.

The gear selector lever was often dif cult to shift. The hydrostatic speed control lever usually had to be momentarily activated to aid shifting. The cylinder speed adjusting crank was awkward to reach and stiff to turn. The unloading auger swing control was dif cult to reach and operate when the unloading auger lever was engaged.

Occasionally, the concave could not be raised to obtain minimum concave clearance due to material build-up on the concave adjusting linkages. It is recommended that the manufacturer consider modi cations to prevent material build-up on the concave adjusting linkages.

Header raising and lowering was controlled by a rocker switch conveniently located on the hydrostatic control lever. Lowering rate could be adjusted to suit operator preference. Raising rate was non-adjustable and sluggish.

Instruments: The instrument console for the Massey Ferguson 860 is shown in FIGURE 5. The console is located above the windshield and houses gauges for fuel level, coolant temperature, battery voltage, and engine hours. A digital readout selectively displayed cylinder speed, main countershaft speed, engine speed, and combine ground speed.

FIGURE 5. Instrument Panel Above Windshield.

The warning lights and an audio alarm system warned the operator of excessive hydraulic oil temperature, low engine oil pressure, excessive coolant temperature, air lter restriction, an open stone trap door, parking brake engagement, and a speed reduction in any of the major combine drives. Indicator lights were small and dim making them dif cult to observe in daylight.

The adjustable cylinder speed warning system worked very well and was very useful, warning the operator of cylinder slugging.

The test machine was not equipped with a grain loss monitor.

Lights: The Massey Ferguson 860 was equipped with four forward lights, a grain tank light, an unloading auger light, two tail lights, and warning ashers. Lighting was good for harvesting at night, but long range lighting for road travel was poor. Console lighting was good. The warning lights and tail lights were adequate for safe road transport.

Engine: The engine started easily and ran well. Average fuel consumption was about 4.5 gal/h (20 L/h). Oil consumption was insigni cant. The engine had adequate power for most conditions encountered. The rotary air intake screen was very effective in preventing radiator plugging. The engine air intake used an aspirated precleaner, dust bowl, and two dry element lters. The dust bowl and outer lter required periodic cleaning.

Maneuverability: The Massey Ferguson 860 was very maneuverable. Steering was smooth, easy and responsive. The wheel brakes did not greatly assist in cornering. On dif cult-to-pick corners, the hydrostatic drive made backing up quick and easy.

Stability: The combine was very stable in the eld, even with a full grain tank. Normal caution was required when operating on hillsides and when travelling at transport speeds. The combine transported well at speeds up to 19 mph (30 km/h).

Grain Tank: The Massey Ferguson 860 had a 180 bu (6.4 m^3) open grain tank. The tank lled evenly in all crops provided the levelling auger trough was properly adjusted. The grain level was dif cult to view from the operator's cab. It is recommended that the manufacturer consider improving visibility of the grain level from the operator's station. No full bin warning device was provided on the test machine.

The unloading auger had ample reach and clearance for unloading into most trucks and grain trailers (FIGURE 6). However, the grain discharge was erratic and scattered, and the de ector spout was ineffective in concentrating the stream of grain. A modi ed de ector spout (FIGURE 7), installed by the Machinery Institute, greatly improved grain discharge. It is recommended that the manufacturer consider modifying the de ector shield to control the grain discharge. Unloading on-the-go and topping off loads was convenient as the auger could be easily repositioned from within the cab without signi cantly altering the discharge height. Unloading a full tank of dry wheat took about 120 seconds.

Pickup: The Massey Ferguson 860 was equipped with a 10 ft (3.2 m) hydraulically driven Victory pickup. It is a two roller pickup with rubberized drapers, nylon teeth, an intermediate transfer draper, and a windguard. Picking height was set by castor wheel adjustment while picking angle was determined by the length of the support chains and header height. Draper speed was controlled from the cab.

FIGURE 6. Unloading with Factory Installed Spout.

The pickup performed well in all crops at speeds up to 7.5 mph (12.0 km/h). The windguard was very effective in deflecting material under the table auger, but had to be removed when harvesting rapeseed crops to prevent bunching and excessive shelling.

Stone Protection: The Massey Ferguson 860 was equipped with a manually operated stone trap located ahead of the cylinder and below the front beater. The stone trap worked well in preventing stones and roots from entering the cylinder and concave. The stone trap door was easy to operate using the slug wrench on the hub provided (FIGURE 8).

FIGURE 7. Unloading with Spout Modified by the Machinery Institute.

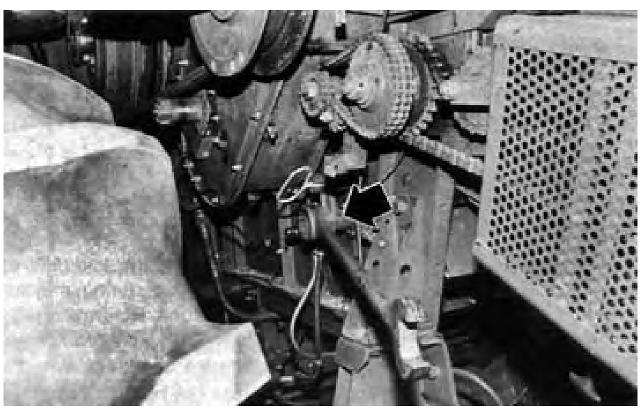

FIGURE 8. Stone Trap Door Handle with Wrench.

Straw Chopper: The optional straw chopper performed well in all crops encountered. However, the average spreading width of about 15 ft (4.6 m) was uneven with more material thrown to the sides. It is recommended that the manufacturer consider modifications to the straw chopper to provide a more uniform spread pattern. The straw chopper could be easily removed or slid to the rear to permit windrowing the straw.

Plugging: The table auger was fairly aggressive and seldom plugged in uniform windrows. However, in bunchy rapeseed windrows, the table auger frequently plugged. It could usually be cleared by rotating the header drive backwards with the slug wrench (FIGURE 9). The paddle feeder worked well in most crops, but plugged occasionally in rapeseed crops. Unplugging was difficult as the feeder slip clutch often slipped when reversing the feeder with the slug wrench.

The cylinder was very aggressive and seldom plugged. The cylinder could usually be unplugged in ten minutes, by lowering the rear of the concave, shifting the cylinder drive to low speed and powering the slug through. The cylinder could also be reversed using the slug wrench on the cylinder hub.

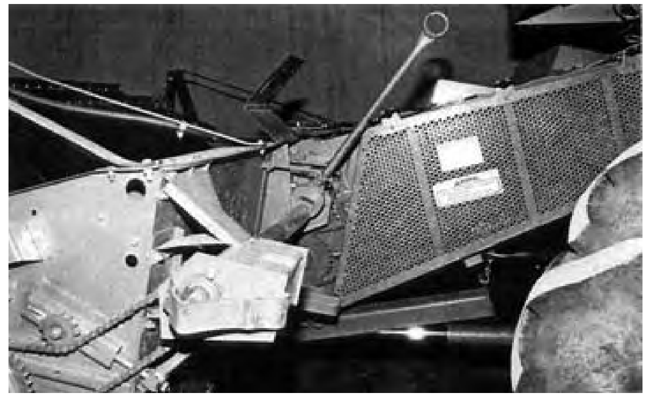

FIGURE 9. Wrench and Hub for Reversing Header.

Machine Cleaning: Cleaning the Massey Ferguson 860 for combining seed grain was time consuming and laborious. The stone trap could be easily cleaned. The center section of the grain tank unloading cross auger was not accessible and could not be completely cleaned. The sieves were quick and easy to remove for cleaning the return and clean grain cross augers. The grain pan beneath the concave was very difficult to clean. Cleaning the outside of the machine was quite easy.

Lubrication and Service: The Massey Ferguson 860 had 35 pressure grease fittings. Six required greasing every 10 hours, twenty-four required greasing every 50 hours, and five required greasing every 2000 hours. Most grease fittings were easily accessible. The use of grease banks greatly improved the ease of lubrication. The engine was accessible from the top and front and could be serviced quite easily.

The hydrostatic and hydraulic oil systems used the same reservoir, which was easily accessible and convenient to service.

EASE OF ADJUSTMENT

Field Adjustment: The Massey Ferguson 860 was easy to adjust and could be set by one person. Cylinder speed and concave clearance were adjusted from within the cab while fan speed and shoe settings were set on the combine. The return tailing could not be conveniently inspected. A method of sampling return tailing would be beneficial in setting the combine. It is recommended that the manufacturer consider supplying a safe convenient apparatus to permit sampling of the return tailings.

Concave Adjustment: The Massey Ferguson 860 had a single segment concave that was levelled at the front with an adjustable eccentric mechanism and with two turnbuckles at the rear. Front and rear clearances could be gauged through inspection ports on either side of the machine. Suitable initial concave clearances with the operator's control lever in the fifth notch were 0.30 in (8 mm) at the leading bar and 0.13 in (3 mm) at the trailing bar. The control linkage opened the leading edge faster than the trailing edge. Leading bar clearances varied from 0.2 to 0.9 in (6 to 24 mm) while rear bar clearances varied from 0.08 to 0.25 in (2 to 6 mm).

Once initial concave clearances were set, the operator could vary the clearance, to suit crop conditions, from within the cab. Suitable concave clearance settings for harvesting were: number 1 position for hard red spring wheat, number 3 for barley and fall rye, and number 9 for rapeseed crops.

The wide spaced concave was used throughout the entire test.

Cylinder Adjustment: The cylinder was driven through a two speed gear box and a variable pitch belt drive. Cylinder speed could be varied from 380 rpm to 800 rpm in low range and from 640 rpm to 1300 rpm in high range. Cylinder speed was adequate for all crop conditions encountered. Suitable cylinder speeds for threshing were, 900 to 1100 rpm in hard red spring wheat, 800 to 970 rpm in barley, 500 to 570 rpm in rapeseed, and 700 to 750 rpm in fall rye.

Shoe Adjustment: The Massey Ferguson 860 was equipped with a triple sieve cascade shoe, a variable speed fan and a wind board.

The cascade shoe consisted of three sets of sieves with ve adjustable lip sections and one xed round hole screen. The sieve adjusting levers were accessible from the rear of the machine. In barley, awns and dirt had to be frequently cleaned from the grain pan, to prevent uneven feeding and poor shoe performance.

The fan speed was varied by a crank operated variable pitch belt drive. The standard fan sheave was used throughout the test. It provided fan speeds from 620 to 1100 rpm. An optional slow speed sheave was available, but was not required for the crops encountered. For most crops, the wind board was set to direct the air blast to the front of the shoe.

In some crop conditions it was not possible to adjust the shoe for satisfactory performance. The left side of the shoe often plugged with material (FIGURE 10). Increasing fan blast or directing the air blast farther to the rear reduced plugging slightly, but increased grain loss over the rest of the shoe. Changing the 0.31 in (8 mm) round hole sieve to a 0.44 in (11 mm) sieve helped but failed to eliminate the problem. It is recommended that the manufacturer consider modi cations to improve air distribution to the cleaning shoe.

The return tailings were delivered to a rethresher, which discharged the material back onto the straw walker grain pan.

Header Adjustments: The Massey Ferguson 860 was evaluated using a windrow pickup header only. The table could easily be removed by one person in about 15 minutes. The feeder and header assembly could be removed by two people in about one hour.

Adjustments were provided for pickup speed, header levelling, header lowering rate, table auger clearances, and auger nger and feeder paddle timing.

Slip Clutches: Individual slip clutches protected the table auger, feeder paddles and return elevator.

RATE OF WORK

Average Workrates: TABLE 3 presents the average workrates for the Massey Ferguson 860 in all crops harvested during the test. Average workrates are affected by crop conditions, windrow quality, eld conditions, and availability of grain handling equipment; therefore they should not be used to compare combines tested in different years. Average workrates varied from 266 bu/h (6.1 t/h) in 27 bu/ac (1.5 t/ha) Regent rapeseed to 452 bu/h (12.3 t/h) in 42 bu/ac (2.8 t/ha) Sinton wheat.

FIGURE 10. Overloading of the Left Section of the Shoe.

TABLE 3. Average Workrates

		Average Yield		Average Speed		Average Workrates			
Crop	Variety	bu/ac	t/ha	mph	km/h	ac/h	ha/h	bu/ac	t/h
Barley	Bonanza	50	2.7	12.5 to 4.0	4.0 to 6.5	9.1	3.7	440	9.6
Barley	Elrose	52	2.6	3.5	5.5	7.9	3.2	418	9.1
Rapeseed	Regent	27	1.5	4.0	6.0	10.6	4.3	266	6.1
Rye	Puma	33	2.1	4.0 to 4.5	6.0 to 7.5	10.4	4.2	336	8.6
Wheat	Benito	30	2.0	3.5	5.0	9.9	4.0	293	8.0
Wheat	Neepawa	33	2.2	1.5 to 3.0	2.5 to 5.0	10.4	4.2	321	8.8
Wheat	Park	25	1.7	3.0	5.0	12.1	4.9	300	8.2
Wheat	Sinton	42	2.6	3.0	5.0	11.1	4.5	452	12.3

Maximum Feedrates: The workrates in TABLE 3 represent average workrates at acceptable loss levels. In most crops, higher feedrates could be attained when operating near the engine power limit. The maximum acceptable feedrate was usually limited by grain loss while the maximum feedrate was limited by engine power in heavier crops and by pickup performance in light crops. Throughput was slightly reduced in tough crops.

Capacity: Combine capacity is the maximum rate at which a combine, adjusted for optimum performance, can harvest a crop at a speci ed total loss level. Many crop variables affect combine capacity. Crop type and variety, grain and straw yield and moisture content, local climatic conditions, and windrow quality can all cause capacity variations.

MOG Feedrate, MOG/G Ratio, and % Loss: When determining combine capacity, combine performance and crop conditions must be expressed in a meaningful way. The loss characteristics of a combine depend mainly on two factors, the quantity of the straw and chaff being processed and the quantity of grain being processed. The mass of straw and chaff passing through a combine per unit of time is called MOG Feedrate. MOG is the abbreviation for "Material-Other-than-Grain" and represents the mass of all plant material passing through the combine except for the grain or seed.

The mass of grain or seed passing through the combine per unit of time is called the Grain Feedrate. The ratio of MOG Feedrate to the Grain Feedrate, abbreviated as MOG/G, indicates how dif cult a crop is to separate. For example, if a combine is used in two wheat elds of identical yields, one with long straw and one with short straw, the combine will have better separation ability in the short crop and be able to operate faster. The crop variable is expressed as MOG/G ratio. MOG/G ratios for prairie wheat crops vary from about 0.5 to 1.5.

Grain loss from a combine is of two main types, unthreshed grain still in the head, and threshed grain, which is discharged with the straw and chaff. Unthreshed grain is called Cylinder Loss. Free grain in the straw and chaff is called Separator Loss and consists of shoe and walker loss. Losses are expressed as a percentage of the total grain passing through the combine.

Combine capacity is expressed as the maximum MOG Feedrate at which total grain loss (cylinder loss plus separator loss) is 3% of the total grain yield.

Capacity of the Massey Ferguson 860: TABLE 4 presents capacity results for the Massey Ferguson 860 in six different crops. MOG Feedrate for a 3% total grain loss varied from 312 lb/min (8.5 t/h) in 56 bu/ac (3.0 t/ha) Bonanza barley to 502 lb/min (13.7 t/h) in 46 bu/ac (3.1 t/ha) Neepawa wheat.

GRAIN LOSS CHARACTERISTICS

The grain loss characteristics of the Massey Ferguson 860 in the six crops described in TABLE 4 are presented in FIGURES 11 to 16.

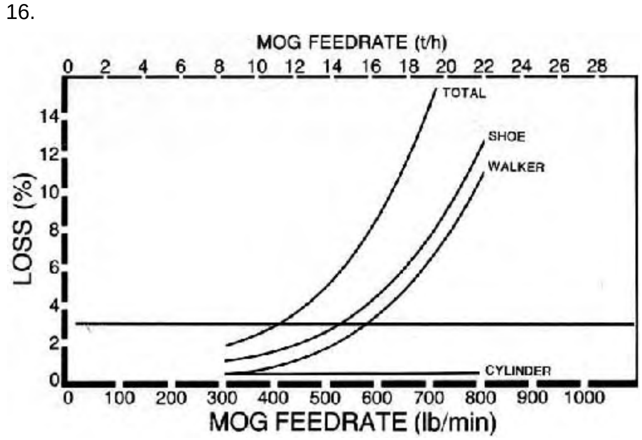

FIGURE 11. Grain Loss in Bonanza Barley (A).

Walker Loss: Grain loss over the straw walkers usually limited capacity in barley crops. In hard-to-thresh wheat crops, straw walker loss did not limit capacity, but would have been signi cant if cylinder loss had been reduced. In the wheat crops tested, the straw walkers had similar loss characteristics in single, side-by-side double and double overlapped windrows.

Shoe Loss: When properly adjusted for crop conditions, the shoe did not usually limit combine capacity. However, at higher feedrates, shoe losses increased rapidly when the left side of the shoe blanketed with material. An improvement in shoe performance would have reduced losses and increased capacity in some crops.

TABLE 4. Capacity at 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	28	8.5[1]	56	3.0	33.4	13.0	1.12	399	10.9	445	9.7	0.5	3.0	Fig. 11
Barley (B)	Bonanza	50	15.2[2]	43	2.3	10.1	12.7	0.72	312	8.5	541	11.8	0.5	1.0	Fig. 12
Wheat (C)	Neepawa	40	12.2[3]	49	3.3	11.0	13.3	0.85	502	13.7	590	16.1	1.0	1.5	Fig. 13
Wheat (D)	Neepawa	40	12.2[3]	46	3.1	9.6	14.4	0.90	499	13.6	554	15.1	1.0	1.5	Fig. 14
Wheat (E)	Neepawa	50	15.2[1]	49	3.3	6.0	11.1	0.87	488	13.3	561	15.3	1.0	1.5	Fig. 15
Wheat (F)	Neepawa	25	7.6[2]	48	3.2	6.0	11.1	0.92	455	12.4	495	13.5	1.5	2.0	Fig. 16

[1]Single Windrow
[2]Double Windrow (overlapped by 1/3)
[3]Double Windrow (side by side)

The grain sample was usually clean in wheat and barley with average dockage between 1.5 and 3.0%.

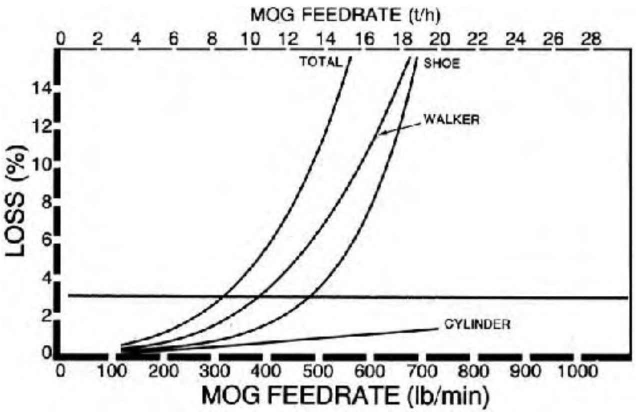

FIGURE 12. Grain Loss in Bonanza Barley (B).

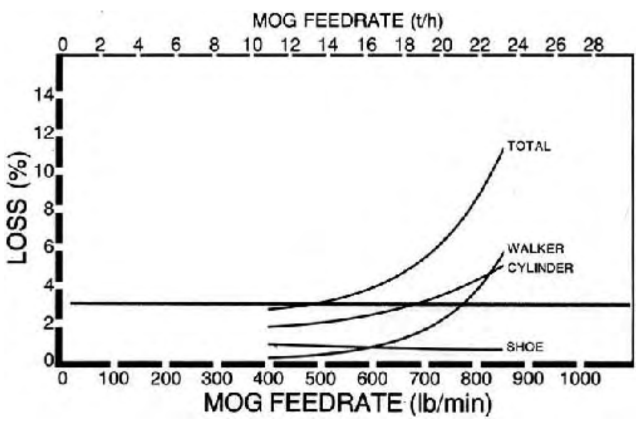

FIGURE 13. Grain Loss in Neepawa Wheat (C).

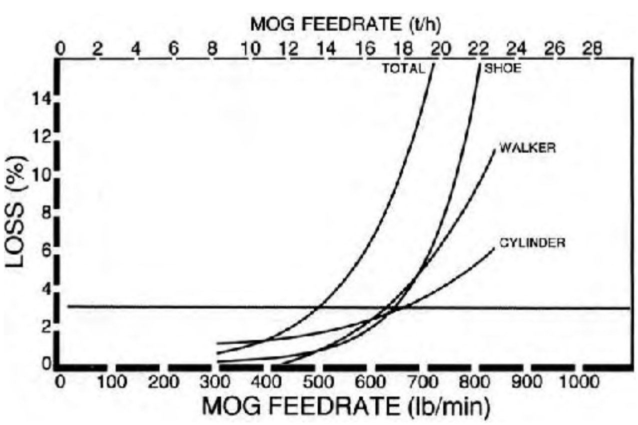

FIGURE 14. Grain Loss in Neepawa Wheat (D).

Cylinder Loss and Grain Damage: Cylinder loss was low in easy-to-thresh crops, but was signi cant in hard-to-thresh wheat crops and occasionally limited combine capacity. In hard-to-thresh wheat crops, grain cracks in the tank were only about 1.5%. For conventional combines, grain cracks of 2 to 4% are not uncommon. This indicates that more aggressive threshing could have been used to reduce cylinder loss and increase combine capacity while still keeping grain cracks to an acceptable level.

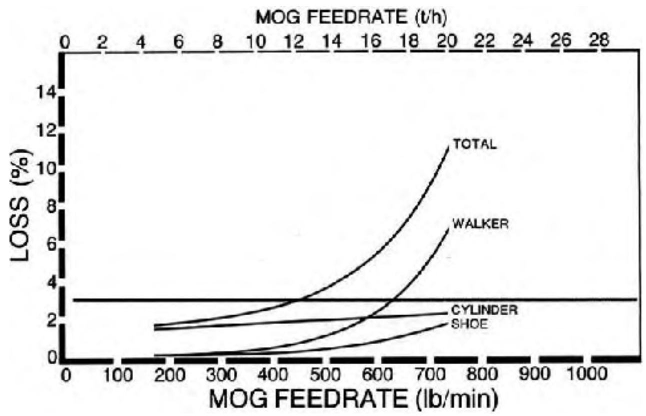

FIGURE 15. Grain Loss in Neepawa Wheat (E).

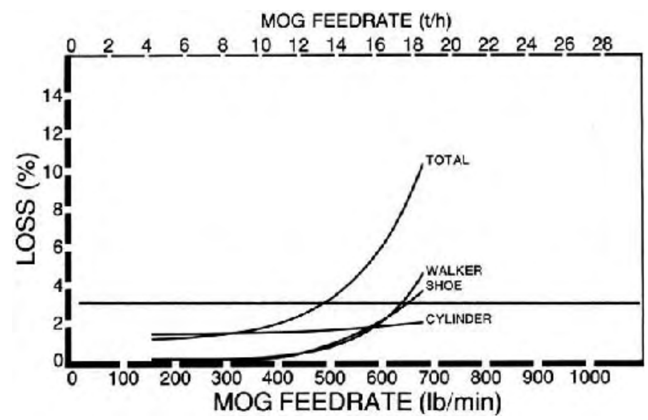

FIGURE 16. Grain Loss in Neepawa Wheat (F).

Body Losses: Leakage of grain from the combine body was negligible in both grain and oil seeds.

Comparison to Reference Combine: Comparing combine capacities is complex because crop and growing conditions affect combine performance with the result that slightly different capacity characteristics can be expected every year. As an aid in determining relative combine capacities, the Machinery institute uses a reference combine. This combine is operated alongside the test machine whenever capacity measurements are made. This permits the comparisons of loss characteristics of every test combine to those of the reference combine, independent of crop conditions. The reference combine used by the Machinery Institute is commonly accepted in the prairie provinces and is described in the Evaluation Report No. 27. See APPENDIX III for the Machinery Institute reference combine capacity results.

FIGURES 17 to 22 compare the total grain losses of the Massey Ferguson 860 and the reference combine in the six crops described in TABLE 4. The shaded areas on the curves are 95% con dence belts. If the shaded areas overlap, loss characteristics of the two machines are not signi cantly different, whereas, if the shaded areas do not overlap, losses are signi cantly different.

The capacity of the Massey Ferguson 860 was much greater than that of the Machinery Institute reference combine. At 3% total loss, the capacity of the Massey Ferguson 860 was about 1.4 times that of the reference in barley and about 1.45 times greater in wheat.

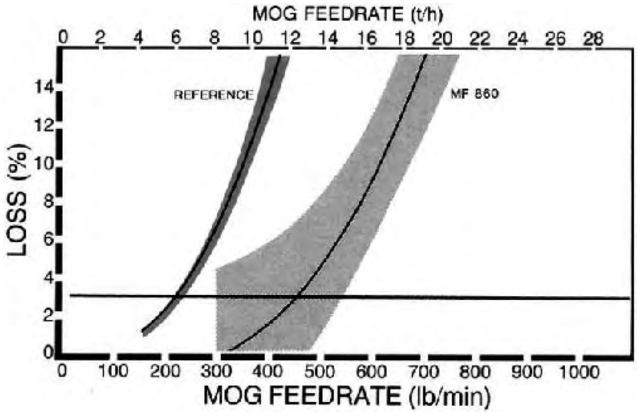

FIGURE 17. Total Grain Loss in Bonanza Barley (A).

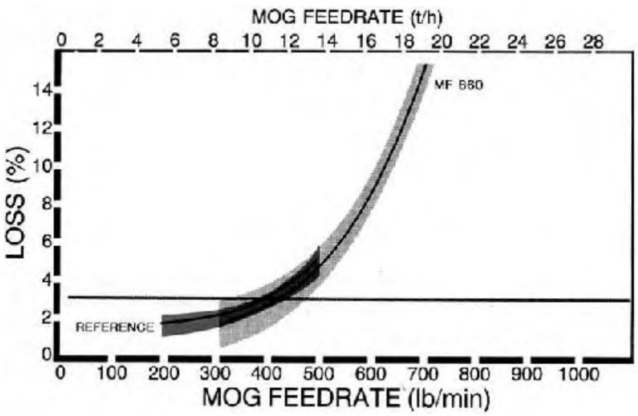

FIGURE 18. Total Grain Loss in Bonanza Barley (B).

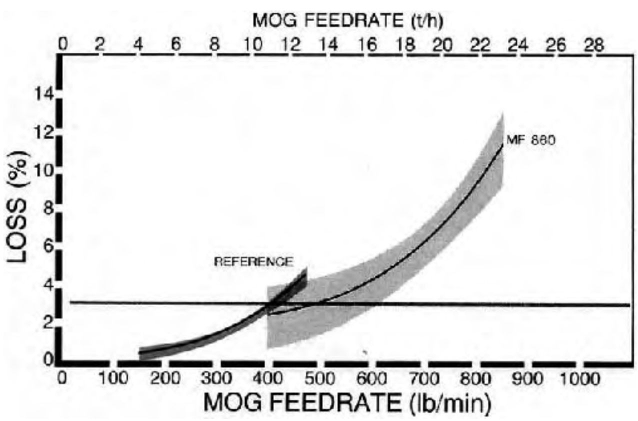

FIGURE 19. Total Grain Loss in Neepawa Wheat (C).

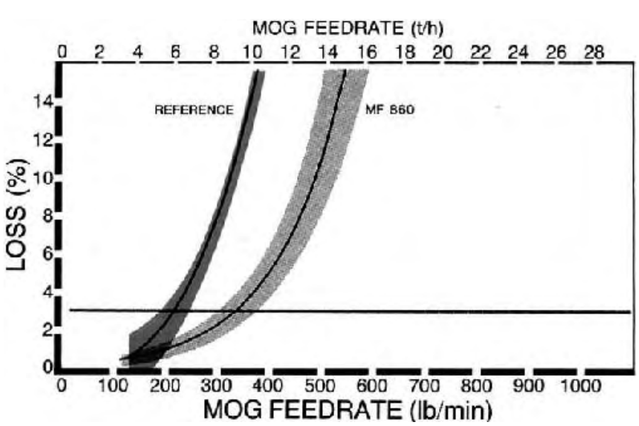

FIGURE 20. Total Grain Loss in Neepawa Wheat (D).

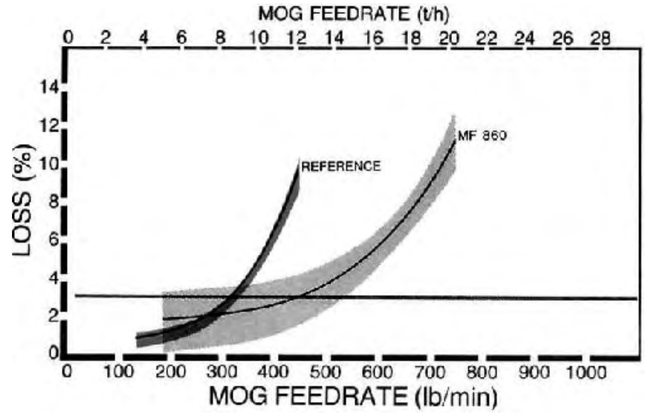

FIGURE 21. Total Grain Loss in Neepawa Wheat (E).

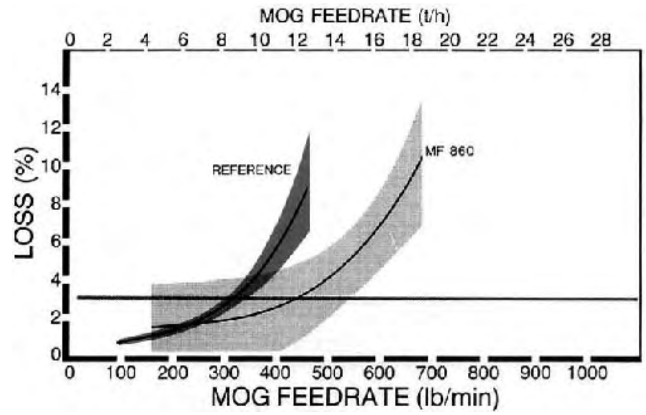

FIGURE 22. Total Grain Loss in Neepawa Wheat (F).

OPERATOR SAFETY

The operator manual emphasized operator safety.

The Massey Ferguson 860 had adequate warning decals to warn of dangerous areas. Most moving parts were well shielded except for the table auger drive chain. It is recommended that the manufacturer consider supplying a hinged shield to cover the table auger drive chain. Most shields were hinged to allow for easy access.

Machine adjustments could be made safely, if safety precautions were followed. However, the fan speed adjusting crank was located too close to the rear wheel to permit safe adjusting while harvesting (FIGURE 23). It is recommended that the manufacturer consider relocating the fan speed control crank to permit safe adjusting while harvesting.

A header lock was provided and should be used when working near the header or when the combine is left unattended. A wrench and hubs were provided for reversing the table auger and cylinder, and for operating the stone trap door.

A slow moving vehicle sign, tail lights, warning lights, turn lights, and rear view mirrors aided in safe road transport.

A re extinguisher (class ABC) should be carried on the machine at all times.

OPERATOR MANUAL

The operator manual was clearly written and well illustrated. It contained much useful information on controls, safe operation, adjustments, crop machine settings, maintenance and lubrication, trouble shooting, and speci cations. Pictures of the combine with the shields in place in the lubrication section made it dif cult to determine where the actual grease ttings were located. It is recommended that the manufacturer consider using combine photos with the shields removed in the lubrication section.

The suggested cylinder and concave settings for various crops were not located in the same section of the manual as the shoe settings. This was inconvenient and it is recommended that the manufacturer consider including all of the recommended settings in one chart.

The suggested initial cylinder, concave and fan settings for rapeseed were inappropriate and it is recommended that the manufacturer consider revising the suggested cylinder, concave and fan settings for rapeseed.

FIGURE 23. Fan Speed Control.

DURABILITY RESULTS

Mechanical History: TABLE 5 outlines the mechanical history of the Massey Ferguson 860 during t53 hours of eld operation while harvesting about 1450 ac (587 ha) of various crops. 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	(ha)
Drives:			
-The pickup drive sprocket, idler sprocket, and drive chain were replaced due to excessive wear from misalignment at	54	567	(229)
-The cylinder drive chain broke and was replaced at	77	813	(329)
-The variable speed cylinder drive belt broke and was replaced at	77	813	(329)
-The straw chopper drive belt broke and was replaced at	130	1374	(555)
Miscellaneous:			
-The hydrostatic transmission heat exchanger was damaged and replaced at	54	566	(229)
-The rear shoe hangers worked out of their lower rubber bushings and were repaired at	134	1417	(573)

DISCUSSION OF MECHANICAL PROBLEMS

Cylinder Drive Chain: A pin in the cylinder drive chain sheared off causing the chain to jam the housing, breaking the cylinder drive belt.

Shoe Hangers: The rear shoe hangers worked their way out of the lower bushing assembly after the cotter pin sheared off. This caused the shoe to perform poorly and it is recommended that the manufacturer consider improving shoe hanger durability.

Hydrostatic Transmission Heat Exchanger: The core on the hydrostatic transmission heat exchanger was damaged by grain and dirt particles blown against it by the heat exchanger fan. The radiating ns were attened, reducing air ow and causing overheating.

The manufacturer installed a new heat exchanger and added a protective expanded metal screen. This prevented damage to the heat exchanger. It is recommended that the manufacturer consider providing a protective screen as standard equipment for the hydrostatic transmission heat exchanger.

APPENDIX I
SPECIFICATIONS

MAKE:	Massey Ferguson Self Propelled Combine
MODEL:	860
SERIAL NUMBER:	Header 1859-66944 Body 1746-15235 Engine XCU 530981 H
MANUFACTURER:	Massey Ferguson Industries Ltd. Toronto, Ontario
WINDROW PICKUP:	
-- make	Victory
-- type	belt and draper
-- pickup width	126 in (3200 mm)
-- number of belts	7
-- teeth/belt	54
-- type of teeth	nylon
-- number of rollers	2
-- height control	castor gauge wheels
-- speed control	variable speed hydraulic drive
-- speed	60 to 435 ft/min (0.3 to 2.2 m/s)
HEADER:	
-- type	center feed with retractable ngers
-- width	13 ft (4 m)
-- auger diameter	20 in (507 mm)
-- feed conveyor	5 fabric belted paddles
-- paddle speed	270 rpm
-- range of picking height	-10 to 52 in (-254 to 1330 mm)
-- number of lift cylinders	2
-- raising time	4.5 s
-- lowering time	variable
-- options	table auger ight extension, straight cut headers and corn headers
FEEDER BEATER:	
-- type	4 blade box
-- diameter	6 in (145 mm)
-- speed	750 rpm
-- options	feeder chain
STONE PROTECTION:	
-- type	stone trap
-- ejection	manually operated access door
-- options	stone trap cover
CYLINDER:	
-- type	rasp bar
-- number of bars	8
-- diameter	22 in (550 mm)
-- width	60 in (1505 mm)
-- drive	variable pitch belt to a two speed gear box
-- speed range - low	380 to 800 rpm
- high	640 to 1300 rpm
-- stripper	bar steel
-- options	slow speed drive
REAR BEATER:	
-- type	drum with 6 triangular bats
-- diameter	15 in (383 mm)
-- speed	740 rpm
CONCAVE:	
-- type	bar and wire (wide space)
-- number of bars	12
-- con guration	11 intervals with 0.31 in (8 mm) wires and 0.55 in (14 mm) spaces
-- total area	1296 in² (0.841 m²)
-- open area	547 in² (0.356 m²)
-- transition grate (total area)	504 in² (0.324 m²)
-- transition grate (open area)	331 in² (0.211 m²)
-- wrap	119°
-- grain delivery to shoe	reciprocating riddle grain pan
-- options	narrow space concave, ller bars, spike tooth
STRAW WALKERS:	
-- type	single step, open bottom
-- number	6
-- length	11.9 ft (3.6 m)
-- housing width	72 in (1820 mm)
-- separating area	9504 in² (6.18 m²)
-- crank throw	2 in (50 mm)
-- speed	215 rpm
-- grain delivery to shoe	reciprocating smooth grain pan
-- options	straw walker risers
SHOE:	
-- type	single action triple screen (cascade)
-- speed	320 rpm
-- chaffer sieve	adjustable lip, 2030 in² (1.320 m²)
-- middle sieve	adjustable lip, 1958 in² (1.270 m²)
-- cleaning sieve	adjustable tip, 1944 in² (1.265 m²)
-- round hole screen	0.44 in (8 mm) diameter holes
-- options	0.06 to 0.625 in (1.5 mm to 16 mm) diameter round hole screens

RETHRESHER:	
-- type	rasp bar cylinder with channel concave
-- number of bars	6 (2 on each)
-- diameter	13 in (333 mm)
-- width	4.5 in (115 mm)
-- speed	840 rpm
CLEANING FAN:	
-- type	dual fans
-- number of blades	6
-- diameter	22 in (550 mm)
-- width (each)	21 in (530 mm)
-- drive	variable pitch belt
-- speed	440 to 550 rpm slow speed 620 to 1100 rp high speed
-- options	slow speed drive (small seed kit)
ELEVATORS:	
-- type	roller chain with rubber ights
-- clean grain (bottom drive)	6 x 10 in (150 x 255 mm)
-- tailings (bottom drive)	4 x 10 in (103 x 255 mm)
GRAIN TANK:	
-- capacity	200 bu (6.4 m^3)
-- unloading time	120 s
-- options	unloader extensions
STRAW CHOPPER:	
-- type	rotor with 40 freely swinging ails
-- speed	2975 rpm
-- options	straw spreader
ENGINE:	
-- make and model	Perkins AV6-540
-- type	4 stroke normally aspirated
-- number of cylinders	8
-- displacement	540 in^3 (8.8 L)
-- governed speed (full throttle)	2500 rpm
-- manufacturer's rating	182 hp (136 kW) @ 2500 rpm
-- fuel tank capacity	75 gal (340 L)
-- options	Perkins AT6.354.4 turbocharged diesel
CLUTCHES:	
-- header	electromagnetic
-- separator	V-belt
-- unloading auger	V-belt
-- traction drive	hydraulic valve
NUMBER OF CHAIN DRIVES:	11
NUMBER OF BELT DRIVES:	23
NUMBER OF GEAR BOXES:	2
NUMBER OF PRELUBRICATED BEARINGS:	104
LUBRICATION POINTS:	
-- 10 hours	6
-- 50 hours	24
-- 2000 hours	5
TIRES:	
-- front	24.5 x 32, R1, l0-ply
-- rear	14L x 16.1, F2, 6-ply
TRACTION DRIVE:	
-- type	hydrostatic
-- speed ranges	
-1st gear	0 to 3.6 mph (0 to 5.8 km/h)
-2nd gear	0 to 5.8 mph (0 to 8.5 km/h)
-3rd gear	0 to 11.7 mph (0 to 18.0 km/h)
-4th gear	0 to 19.0 mph (0 to 30 km/h)
OVERALL DIMENSIONS:	
-- wheel tread (front)	10.7 ft (3.3 m)
-- wheel tread (rear)	7.3 ft (2.2 m)
-- wheel base	13.7 ft (4.2 m)
-- transport height	12.6 ft (3.8 m)
-- transport length	31.7 ft (9.6 m)
-- transport width	14.6 (4.5 m)
-- eld height	13.4 ft (4.1 m)
-- eld length	30.7 ft (9.3 m)
-- eld width	22.8 (7.0 m)
-- unloader discharge height	12.2 ft (3.7 m)
-- unloader clearance height	11.3 ft (3.4 m)
-- unloader reach	9.1 ft (2.8 m)
-- turning radius - left	20.8 ft (6.3 m)
- right	22.0 ft (6.7 m)
MASS: (empty grain tank)	
-- right front wheel	8415 lb (3825 kg)
-- left front wheel	10186 lb (4630 kg)
-- right rear wheel	2497 lb (1135 kg)
-- left rear wheel	2497 lb (1135 kg)
Total	23595 lb (10725 kg)

APPENDIX II
REGRESSION EQUATIONS FOR CAPACITY RESULTS

Regression equations for the capacity results shown in FIGURES 11 to 16 are presented in TABLE 6. In the regressions, C = cylinder loss in percent of yield, S = shoe loss in percent of yield, W = walker loss in percent of yield, F = the MOG feedrate in t/h, while $\ln$ is the natural logarithm. Sample size refers to the number of loss collections. Limits of the regressions may be obtained from FIGURES 11 to 16 while crop conditions are presented in TABLE 4.

TABLE 6. Regression Equations

Crop - Variety	Fig. No.	Regression Equations	Simple Correlation Coefficient	Variance Ratio	Sample Size
Barley - Bonanza	11	$\ln C = -2.34 + 0.68 \ln F$ $S = 0.88 + 0.54 \times 10^{-4} F^4$ $W = 0.13 + 0.50 \times 10^{-4} F^4$	0.58 0.98 0.99	3.06[1] 127.34[2] 2246.89[2]	8
Barley - Bonanza	12	$C = -0.27 + 0.09F$ $\ln S = -2.70 + 0.29F$ $W = 0.20 + 0.26 \times 10^{-2} F^3$	0.94 0.88 0.99	52.20[2] 24.27[2] 307.10[2]	9
Wheat - Neepawa	13	$C = 1.58 + 0.19 \times 10^{-4} F^4$ $S = 1.07 - 0.03F$ $\ln W = -5.26 + 0.30F$	0.82 0.50 0.93	8.16[2] 1.33 24.11[2]	6
Wheat - Neepawa	14	$C = 0.97 + 0.19 \times 10^{-4} F^4$ $\ln S = -5.41 + 0.37F$ $W = -0.80 + 0.45 \times 10^{-4} F^4$	0.99 0.90 0.99	2034.82[2] 16.21[1] 212.99[2]	6
Wheat - Neepawa	15	$C = 1.22 + 0.58 \times 10^{-1} F$ $S = -0.10 + 0.11 \times 10^{-4} F^4$ $\ln W = -3.64 + 0.28F$	0.78 0.70 0.99	7.84[1] 4.71 212.88[2]	7
Wheat - Neepawa	16	$C = 1.44 + 0.49 \times 10^{-5} F^4$ $S = -0.30 + 0.33 \times 10^{-4} F^4$ $\ln W = -5.47 + 0.38F$	1.76 0.63 0.98	7.03[1] 3.21 118.86[2]	7

[1]Signi cant at $P \leq 0.05$
[2]Signi cant at $P \leq 0.01$

APPENDIX III

MACHINERY INSTITUTE REFERENCE COMBINE CAPACITY RESULTS

TABLE 7 and FIGURES 24 and 25 present the capacity results for the Machinery Institute reference combine in wheat and barley crops harvested from 1978 to 1982. FIGURE 19 shows capacity differences in Neepawa wheat for the ve years. The 1982 Neepawa wheat crops shown in TABLE 7 were of lower than average straw yield and better than average grain yield. Most of the crops were hard-to-thresh while the grain moisture was similar to the other years and the straw moisture content was about average.

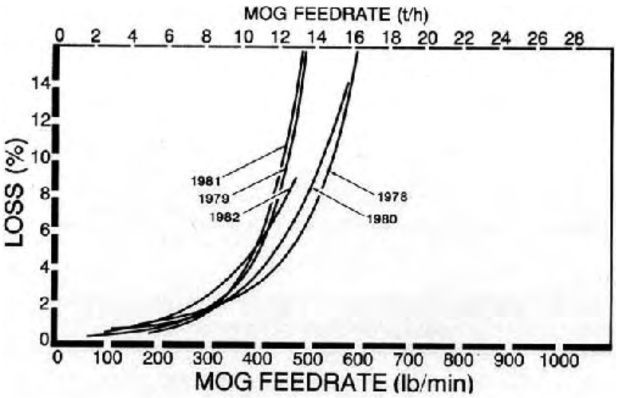

FIGURE 24. Total Grain Loss for the Reference Combine in Neepawa Wheat.

FIGURE 20 shows capacity differences in six-row Bonanza barley for 1978, 1981, and 1982, two-row Fergus barley for 1979 and two-row Hector barley for 1980. The 1982 Bonanza barley crops shown in TABLE 7 were of average straw yield, easy-to-thresh with average grain moisture content. The straw moisture content was average in one crop, but higher in the other.

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.

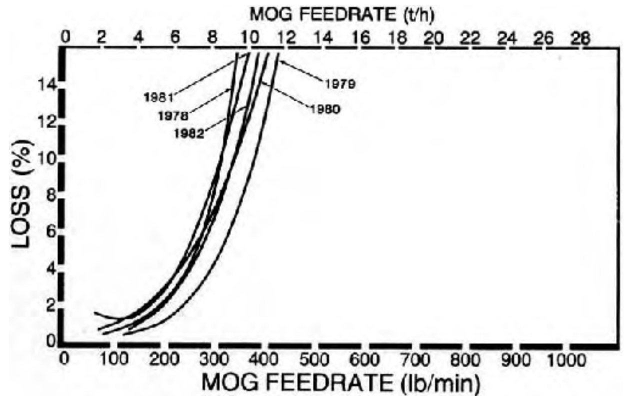

FIGURE 25. Total Grain Loss for the Reference Combine in Bonanza Barley.

TABLE 7. 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 Feedrate		Grain Feedrate		Ground Speed		
Year	Crop	Variety	ft	m	bu/ac	t/ha	Straw %	Grain %	MOG/G Ratio	lb/min	t/h	bu/h	t/h	mph	km/h	Loss Curve
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. 27
	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. 26
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. 27
	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. 26
	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. 27
	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. 26
	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	
1979	Barley	Klages	20	6.1	66	3.67	5.5	11.7	0.64	249	6.8	486	10.6	2.9	4.7	
	Wheat	Neepawa	24	7.3	41	2.77	5.2	14.1	1.21	348	9.5	286	7.6	2.4	3.9	
	Wheat	Neepawa	20	6.1	40	2.67	5.9	14.3	1.09	356	9.7	326	8.9	3.4	5.4	Fig. 26
	Barley	Fergus	24	7.3	64	3.46	8.1	12.5	0.77	268	7.3	435	9.5	2.3	3.7	Fig. 27
1978	Wheat	Canuck	24	7.3	38	2.54	7.1	12.1	1.15	433	11.8	378	10.3	3.5	5.6	
	Wheat	Lemhi[1]	36	11.0	32	2.13	6.6	12.0	0.75	400	10.9	532	14.5	3.9	6.2	
	Wheat	Neepawa	20	6.1	48	3.23	10.4	15.9	1.04	341	9.3	326	8.9	2.8	4.5	Fig. 26
	Barley	Bonanza	20	6.1	75	4.06	7.7	13.5	0.68	224	6.1	413	9.0	2.3	3.6	Fig. 27

[1]Side-by-side Double Windrow
[2]Double Windrows Lapped by 1/3

APPENDIX IV

The following rating scale is used in Machinery Institute Evaluation Reports:

excellent	fair
very good	poor
good	unsatisfactory

APPENDIX V

CONVERSION TABLE

1 inch (in)	= 25.4 millimetres (mm)
1 mile (m)	= 1.6 kilometres (km)
1 pound (lb)	= 0.45 kilograms (kg)
1 gallon (gal)	= 4.5 litres (L)
1 acre (ac)	= 0.40 hectare (ha)
1 horsepower (hp)	= 0.75 kilowatts (kW)
100 bushels	= 3.8 cubic metres (m^3)
100 bushels -wheat	= 2.7 tonnes (t)
-barley	= 2.2 tonnes (t)
-rapeseed	= 2.3 tonnes (t)
-rye	= 2.5 tonnes (t)
100 pounds per minute (lb/min)	= 2.7 tonnes per hour (t/h)

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