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Evaluation Report 226

Co-op Implements 9600 Pull-Type Combine

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

CO-OP IMPLEMENTS 9600 PULL-TYPE COMBINE

MANUFACTURER:
Canadian Co-operative Implements Limited
770 Pandora Avenue East
Winnipeg, Manitoba
R2C 3N1

DISTRIBUTOR:
Canadian Co-operative Implements Limited
770 Pandora Avenue East
Winnipeg, Manitoba
R2C 3N1

RETAIL PRICE:
$36,984.00 (June 1981, f.o.b. Humboldt, with 3.2 m header, 3.2 m Melroe 378 pickup, and straw chopper).

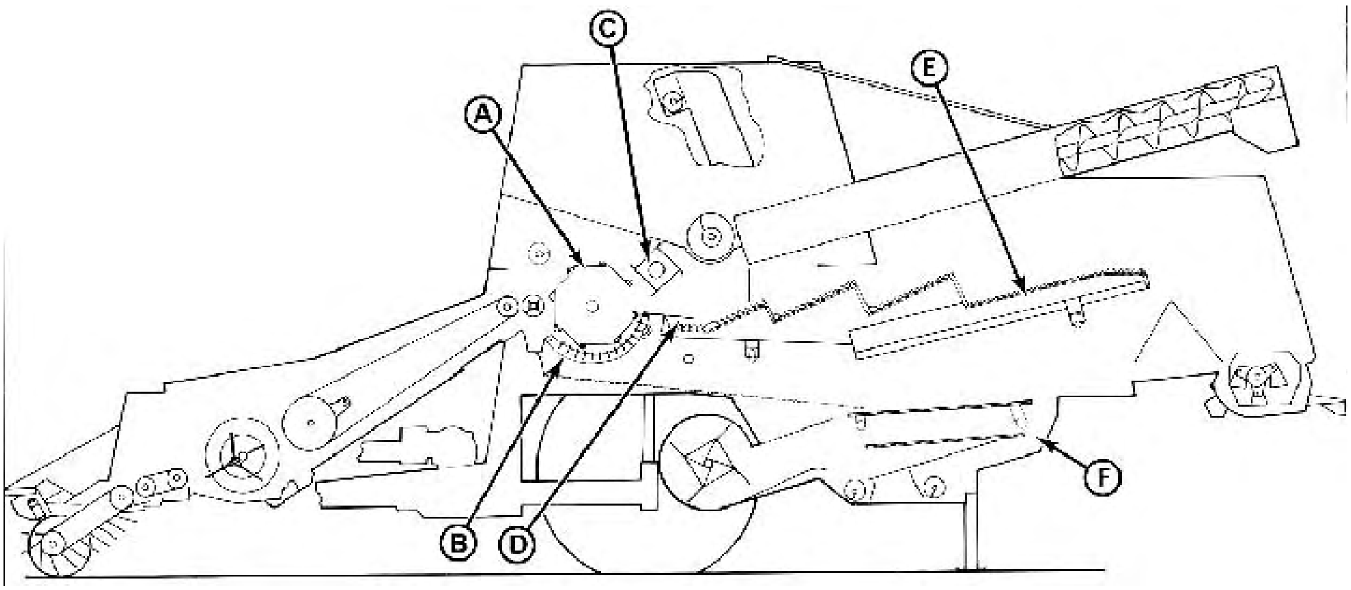

FIGURE 1. Co-op Implements 9600: (A) Cylinder, (B) Concave, (C) Back Beater, (D) Beater Grate, (E) Straw Walkers, (F) Shoe.

SUMMARY AND CONCLUSIONS

Functional performance of the Co-op Implements 9600 pull-type combine was very good in dry and tough grain crops and good in dry and tough oil seed crops.

The MOG feedrate* at 3% total grain loss varied from 10.5 t/h (386 lb/min) in 3.0 t/ha (44 bu/ac) Neepawa wheat to 5.0 t/h (184 lb/min) in 1.6 t/ha (29 bu/ac) Candle canola.

The capacity of the Co-op Implements 9600 was similar to the capacity of the PAMI reference combine for a similar total grain loss. While straw walker loss was the most significant factor affecting capacity in barley, walker and shoe losses were nearly balanced in wheat. Shoe loss did not limit capacity in grain crops. Cylinder losses usually were small in comparison to straw walker loss.

Average power take-off requirements at 3% total grain loss were 31 kW (42 hp) in wheat and 22 kW (29 hp) in barley. The manufacturer recommends use of a 90 kW (120 hp) tractor.

The Co-op Implements 9600 was very maneuverable and was easily changed from transport to field position. Header visibility, ease of handling and control convenience depended on the tractor used. Feedrate control depended upon the range of ground speeds provided by the tractor.

Grain tank visibility was good. Combine lighting provided good night visibility when supplemented by tractor lights. The unloading auger had sufficient reach for easy unloading on-the-go, but clearance between the auger and most truck boxes was marginal.

The combine electronic monitor/control box provided the operator with excellent combine performance information and finger tip control of important functions.

The CI 9600 was easy to adjust for crop conditions. The pickup speed and cylinder speed could be adjusted from the tractor. The concave was inconvenient to adjust while the shoe and fan were easily adjusted. The return tailings were easy to inspect.

The pickup had very good feeding characteristics in all crops. The windguard had to be removed to prevent bunching in rapeseed.

The table auger and feeder had very good capacity in dry cereal and oil seed crops and plugging was infrequent. Cylinder plugging occurred occasionally. Cylinder access was fair.

The stone trap stopped most stones and roots before they entered the cylinder. The stone trap was inconvenient to service.

Ease of servicing was very good as all grease fittings were accessible.

The CI 9600 transported well at speeds up to 32 km/h (20 mph). Transport width was narrow enough for easy movement on most roads, but rear visibility was restricted.

No safety hazards were encountered when operating with normal caution. The operator's manual was clearly written and adequately illustrated.

Some minor durability problems occurred during the test.

The MOG feedrate (material-other-than-grain feedrate) is the mass of straw and chaff passing through a combine per unit of time.

RECOMMENDATIONS

It is recommended that the manufacturer consider:
1. Improving switch lighting and identification on the monitor/ control box and adding guards to prevent accidental switch engagement.
2. Modifying the pickup drive to provide slower pickup speeds.
3. Modifications to reduce feeder plugging in flax straw.
4. Modifications to the cylinder rocking wrench and hub to improve ease of use.
5. Providing a more convenient concave adjusting mechanism.
6. Increasing the range of adjustment for table auger clearance to make smaller clearances possible.
7. Modifying the grain tank levelling auger chain tension block to reduce wear.

Chief Engineer -- E. O. Nyborg
Senior Engineer -- J. D. MacAulay
Project Engineer -- P. D. Wrubleski

THE MANUFACTURER STATES THAT

With regard to recommendation number:

1. This recommendation will be considered in future design.
2. Optional sprockets are now available to provide the required speed ranges.
3. We have had no previous reports of feeder plugging problems in flax. This concern will be investigated.
4. A new design is under construction for this wrench.
5. Most farmers have a ratchet in their socket set, however, we will consider the addition of a ratchet for future production.
6. The range of adjustment has been increased for 1981 production.
7. A change was made in 1981 production to eliminate this problem. A field change up has been provided for all 1980 CI combine customers.

GENERAL DESCRIPTION

The Co-op Implements 9600 is a power take-off driven, pull-type combine with a transverse-mounted, tangential threshing cylinder, concave, straw walkers and cleaning shoe. Threshing and initial separation occur 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 was equipped with a 3.2 m (10.6 ft) off-set header, 3.2 m (1.26 in) Melroe 378 pickup, and straw chopper.

The separator drive is controlled by the tractor power take-off clutch. The header and unloading auger drives are controlled by electro-magnetic clutches, while header height is controlled by the tractor hydraulics. Harvesting functions are monitored with a monitor/control box placed in the tractor cab.

Cylinder and pickup speed are electrically controlled from the combine monitor/control box on the tractor. Concave clearance is adjusted using wrenches to change the free length of the concave positioning bolt. Fan speed is adjusted with a crank operated variable speed belt drive while the sieves are adjusted with rods on the side of the combine. Return tailings may be inspected through a slide door on the tailings return auger.

Detailed specifications are given in APPENDIX I.

SCOPE OF TEST

The Co-op Implements 9600 was operated in the conditions shown in TABLES 1 and 2 for 170 hours while harvesting about 305 ha (754 ac). It was evaluated for ease of operation, ease of adjustment, rate of work, grain loss characteristics, grain loss monitor accuracy, power requirements, operator safety and suitability of the operator's manual. Throughout the test, comparisons were made to the PAMI reference combine.

TABLE 1. Operating Conditions

Crop	Variety	Average Yield t/ha	Swath Width m	Hours	Field Area ha
Barley	Betzes	2.6	6.1	9.5	16
Barley	Fergus	2.4	5.1 to 7.2	12.0	21
Barley	Hector	3.1	6.1	5.5	9
Barley	Klages	2.5	6.0 to 7.5	9.5	18
Barley	Melvin	2.4	6.1	2.5	5
Fall Rye	Cougar	1.3	4.4 to 11.9	18.5	30
Fall Rye	Puma	1.1	6.1	23.0	51
Flax	Dufferin	1.8	5.8 to 6.1	6.5	11
Rapeseed	Candle	1.6	5.1 to 6.4	13.0	18
Rapeseed	Torch	1.1	6.1	20.0	47
Wheat	Neepawa	3.0	6.1 to 7.3	50.0	79
Total				170.0	305

TABLE 2. Operation in Stony Fields

Field Condition	Hours	Field Area (ha)
Stone Free	55	98
Occasional Stones	105	190
Moderately Stony	10	17
Total	170	305

RESULTS AND DISCUSSION

EASE OF OPERATION

Hitching: A tractor with a standard 35 mm (1.38 in) spline 1000 rpm power take-off and 12 volt negative ground electrical system was needed to power the Co-op Implements 9600 combine.

The following adjustments were needed to initially couple the tractor to the combine:

The monitor/control box had to be mounted in a suitable location in the tractor cab and connected to the tractor electrical system. The tractor drawbar had to be pinned in-line with the power take-off shaft to provide the standard 406 mm (16 in) distance between the end of the tractor power take-off and the hitch pin. The drawpole had to be levelled to suit tractor drawbar height by adjusting the drawpole clevis. The tire bumpers had to be adjusted to suit tractor wheel tread and the power take-off shaft connected to the tractor. In addition, one hydraulic outlet was needed to operate the header lift, while the electrical coupler had to be spliced into the tractor electrical system to operate the warning lights.

The hitch jack was convenient to use. A hitch safety chain was supplied as standard equipment.

Operator Location: Operator comfort and visibility depended primarily on the tractor used. Characteristic of pull-type combines, the operator has less "feel" for combine performance and must rely more on monitoring equipment.

Controls: The separator drive was controlled by the tractor power take-off clutch, while header height was controlled by the tractor hydraulics. The range of available ground speeds depended upon the tractor. Switches on the monitor/control box (FIGURE 2) operated the electro-magnetic header clutch, electro-magnetic grain unloading clutch, the electric cylinder speed control, the electric pickup speed control and the combine lights. It is recommended that the manufacturer improve switch identification, provide guards around the switches to prevent accidental engagement and provide night lighting for the switches.

FIGURE 2. Electric Monitor/Control Box.

Electronic Monitor/Control Box: In addition to the electric controls, the monitor contained an hour meter, a grain loss monitor, a shaft speed monitor and a digital tachometer, which displayed either the primary counter shaft speed cylinder speed or fan speed.

The shaft speed monitor warned of speed reductions in the clean grain cross auger, the tailings return cross auger, the straw walkers, the straw chopper, the table auger and the shoe. Warning lights also indicated straw walker plugging, unloading auger operation, and a full grain tank. A malfunction was indicated by a flashing light and audio alarm.

Grain Loss Monitor: The grain loss monitor readout and controls were located in the combine monitor/control box (FIGURE 2). Grain loss was sensed by four pad sensors; two located behind the shoe and two behind the straw walkers.

When the monitor/control box was mounted for convenient access to the control switches, loss monitor meter visibility was restricted. The meter was difficult to read due to its small size and poor contrast between the needle and meter face. Meter illumination provided good night visibility, but did not improve readability.

Lights: The CI 9600 was equipped with three field lights; one for the header, one for the grain tank, and one for the unloading auger. Warning lights and taillights were adequate for safe road transport.

Stability: In normal field operation, the CI 9600 was quite stable when the grain tank was less than three-quarters full. With a full grain tank, the combine rocked sideways on rough fields or when changing speed. The centre of gravity, with the grain tank three-quarters full, was 191 mm (7.5 in) in front of the axle, 59 mm (2.3 in) left of the axle centre-line, and 1954 mm (77 in) aboveground. With the grain tank three-quarters full, the hitch load became negative when travelling up slopes greater than 9 degrees. Normal care had to be used when turning corners on hillsides. The tractor had to be properly ballasted on hilly fields.

Maneuverability: The CI 9600 was very maneuverable and easily picked most windrow corners. The pickup, header and drawpole position allowed windrows to be fed directly in line with the feeder house opening (FIGURE 3). A maximum outside tractor wheel width of 2440 mm (96 in) allowed direct feeding of fluffy windrows. The minimum windrower width to permit passing between windrows was 4880 mm (16 ft) with a 2440 mm (96 in) tractor width (FIGURE 4).

FIGURE 3. In-Line Feeding of Windrow.

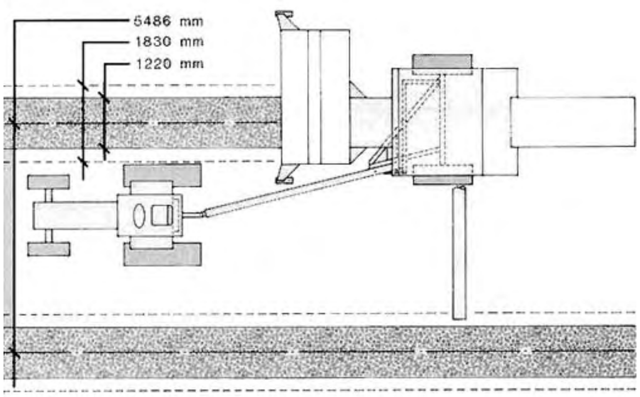

FIGURE 4. Tractor Wheel and Windrow Spacing Needed for In-Line Feeding.

Grain Tank: The grain tank volume was 5.1 m³ (140 bu). The tank filled evenly and completely when the levelling auger sections were properly adjusted. The full-grain-tank sensor signalled shortly before the tank overflowed.

The unloading auger was easy to swing into field position by one person using the folding over-centre brace. The auger locked easily into place with a second over-centre lock.

The unloading auger had ample reach for easy on-the-go unloading, but clearance was marginal when unloading into trucks with high boxes or box extensions (FIGURE 5). The auger delivered an even compact stream of grain and unloaded a full tank of dry wheat in 109 seconds. The empty unloading auger continued to turn for several seconds after it was disengaged.

Pickup: The CI 9600 was equipped with a 3215 mm (126 in) Melroe 378 two roller draper pickup with steel teeth, an intermediate transfer draper, and windguard.

The picking height was controlled by castor wheel adjustment while picking angle was determined by adjustable support chains and header height setting.

The pickup performed well in most conditions, picking cleanly and feeding windrows under the table auger.

Pickup speed could be varied electrically from the operator station. The speed change was quite irresponsive. The draper speed ranged from 0.78 m/s to 1.27 m/s (154 ft/min to 250 ft/min). The slowest speed was too fast, causing shelling in heavy rapeseed windrows. It is recommended that the manufacturer consider modifying the pickup drive to provide a minimum draper speed of 0.6 m/s (118 ft/min).

FIGURE 5. Unloading Auger Clearance.

Stone Protection: The stone trap, located in front of the cylinder, quickly filled with chaff and grain, but trapped most stones and roots. The trap was quite accessible (FIGURE 6), but dirty and inconvenient to clean, as cleaning required hand removal of foreign objects. The entire stone trap assembly was removable to provide access to the cylinder.

FIGURE 6. Stone Trap Clean-Out Door.

Straw Chopper: The optional straw chopper performed well in all crops. Straw length was varied by adjusting knife protrusion into the chopper housing. The width of spread could be changed by adjusting the angle of the deflector fins and the angle of the tailplate. Spread widths of 5 m (16 ft) were attainable in most crops. Wind greatly reduced spreading effectiveness. When straw was windrowed, the straw chopper did not need to be removed, but could be slid forward on rails. Changing chopper position took one man about 10 minutes.

Plugging: The table auger and feeder performed well, but plugged frequently when operating in bunchy, damp, or wild oat infested windrows. Table auger capacity depended on the feeder drive slip clutch tension and auger-to-table clearance.

The table auger and feeder could be unplugged by reversing the header using the rocking hub on the left end of the table auger (FIGURE 7). The pickup windguard restricted access for unplugging the table auger. The windguard had to be removed when combining rapeseed to prevent excessive shelling and bunching.

The feeder had high capacity in most crops. In flax, however, straw bunched on the top side of the feeder housing behind the carrier slats (FIGURE 8), causing excessive chain tension. It is recommended that the manufacturer consider modifications to reduce feeder plugging in flax straw.

The cylinder occasionally plugged in bunchy crops due to cylinder belt slip. The cylinder variable speed belt had to be properly tensioned to prevent slip in tough crops.

Unplugging the cylinder required lowering the concave, removing the stone trap panel for access to the bottom of the cylinder, or the two top panels for access to the top of the cylinder. The cylinder could be rotated backwards with a rocking wrench and hub.

Since the hub had only four positions, it was difficult to conveniently position the wrench for maximum torque application. The stone trap was difficult to replace by one person. It is recommended that the manufacturer consider modifications to the cylinder rocking wrench and hub to improve ease of use.

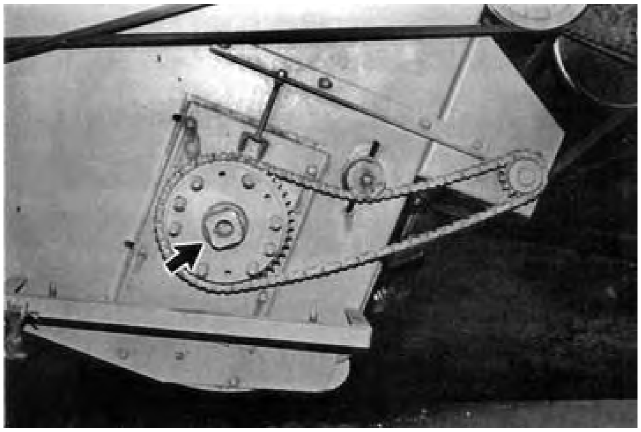

FIGURE 7. Rocking Hub on Table Auger.

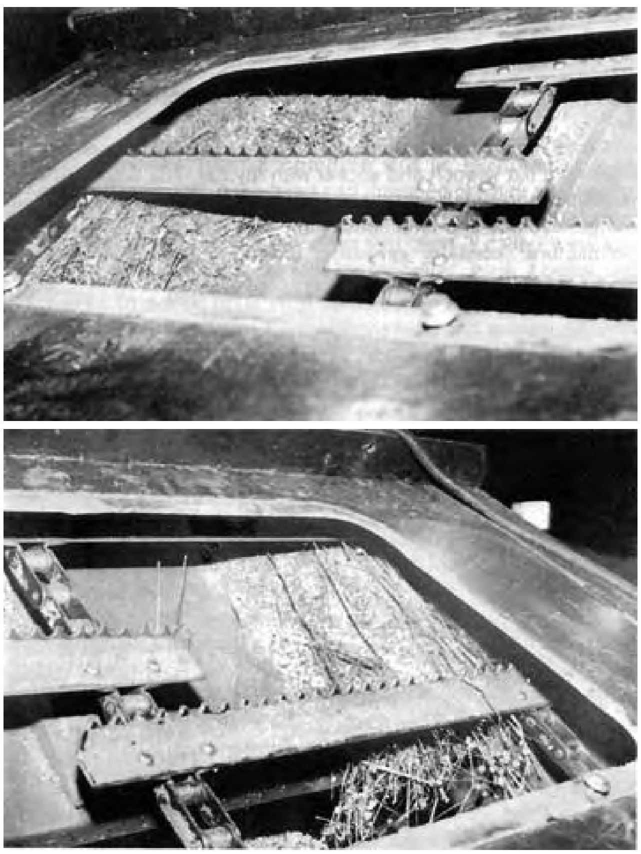

FIGURE 8. Flax Straw Bunching in Feeder Housing.

Machine Cleaning: Cleaning of the CI 9600 for combining seed grain was time consuming. The stone trap was easy to remove and clean, but inconvenient to replace. The grain pan was very difficult to clean. The chaffer and sieve were easy to remove and the clean grain and tailings auger troughs could be cleaned by removing the pans beneath the augers. The grain tank was easily accessible and convenient to clean. Dust and chaff that accumulated on the combine body was easy to clean. The top of the fan housing accumulated a large amount of chaff, but was easy to clean.

Transporting: The CI 9600 was easy to place in transport position. The hitch locking wedge had to be removed by hand and the tractor either backed or driven ahead to pivot the drawpole (FIGURE 9).

The CI 9600 transported well at speeds up to 32 km/h (20 mph). Transport width was narrow enough for easy movement on most roads, but rear visibility was restricted. The combine was adequately equipped with warning lights and a slow-moving vehicle sign for safe transport on public roads.

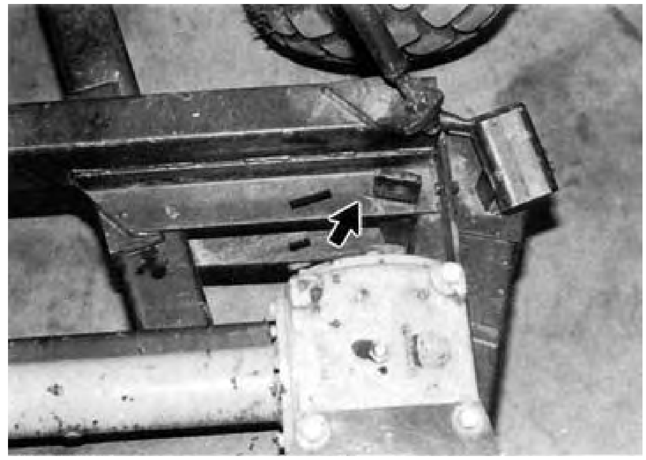

FIGURE 9. Drawpole Position Lock.

Lubrication: The CI 9600 had twenty-two pressure grease fittings. Three required greasing every 10 hours and nineteen needed greasing every 50 hours. The main gearbox required a weekly check and the wheel bearings required seasonal checks. The grease fittings all were accessible.

EASE OF ADJUSTMENT

Field Adjustment: The Co-op Implements 9600 was easy to set for field conditions. As with all pull-type combines, having a second person available for adjusting, enabled faster setting.

Concave Adjustment: The CI 9600 had a single segment high wrap concave. The concave could be levelled with front and rear eyebolts. Front and rear concave clearances were gauged through inspection holes (FIGURE 10). Once the concave had been initially set, clearances were changed by unlocking and rotating the adjusting bolt (FIGURE 11). The control linkage was designed so the leading concave bar opened at five times the rate of the trailing bar.

FIGURE 10. Concave Levelling and Inspection.

Changing concave clearances was slow and inconvenient, requiring a flat wrench and socket with ratchet. The adjusting bolt was difficult to reach and the thread pitch made large clearance changes tedious and time consuming. It is recommended that the manufacturer consider providing a more convenient concave adjusting mechanism.

Leading bar clearances varied from 10 to 30 mm (0.39 to 1.18 in) while trailing bar clearances varied from 4 to 8 mm (0.16 to 0.32 in). At minimum setting, the cylinder-to-concave clearance was zero in the centre segment of the concave, while rear clearance was still 4 mm (0.16 in), due to the arc of the concave.

Suitable front concave clearances were from 15 to 20 mm (0.59 to 0.79 in) in wheat and barley, 15 to 25 mm (0.59 to 0.98 in) in rapeseed and 10 mm (0.39 in) in flax.

Cylinder Adjustment: The cylinder was equipped with an electrically operated variable speed drive, controlled and monitored from the tractor. The variable drive provided speeds from 580 to 1130 rpm. This range was adequate for all crops.

FIGURE 11. Concave Adjustment.

Suitable cylinder speeds were from 800 to 950 rpm in hard spring wheat, 700 to 850 rpm in barley, 500 to 650 rpm in rapeseed, 700 to 900 rpm in fall rye and 950 to 1000 rpm in flax.

Shoe Adjustment: The chaffer and sieve were easily adjusted with levers on the side of the combine (FIGURE 12) while the chaffer extension was not adjustable. Fan speed was varied with a crank operated variable speed drive (FIGURE 12), and was displayed on a digital tachometer. The fan adjusting crank was easy to reach, but difficult to turn. Return tailings were conveniently sampled through the lower tailings auger inspection door (FIGURE 13).

The shoe was single acting and therefore somewhat susceptible to spearing in cereal grain crops (FIGURE 14). Most of the spearing resulted from reducing the combine separator speed, habitually done when topping off a load of grain while stationary. To reduce spearing, the combine should be run out completely before reducing the separator speed.

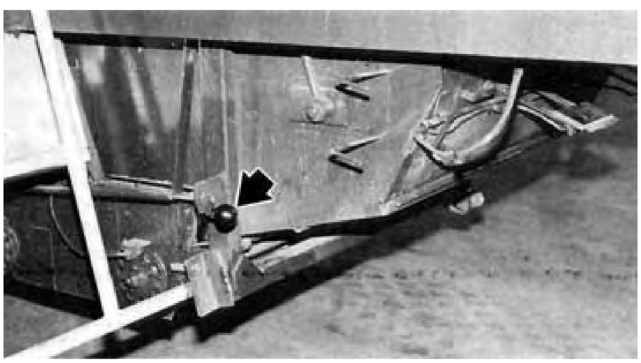

FIGURE 12. Fan Speed Adjustment.

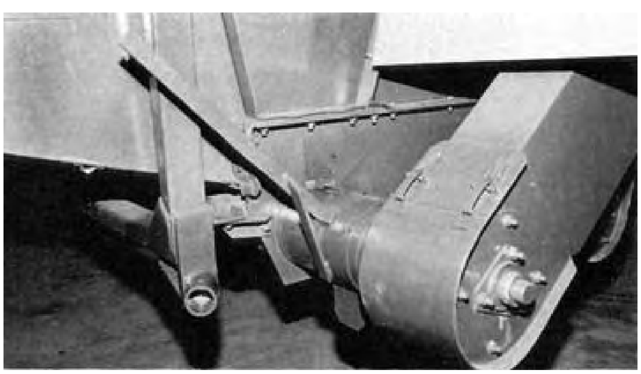

FIGURE 13. Return Tailings Inspection Door.

The shoe was easy to set and performed well in all crops. Optional fan doors were needed in rapeseed. The foreign material in the tank sample varied from 0.3 to 1.1 % in most crops.

It was important to feed the windrow centred on the feeder housing and to load the full cylinder width to ensure uniform shoe loading. As with most combines, shoe losses increased noticeably on side slopes greater than 5 degrees due to non-uniform shoe loading.

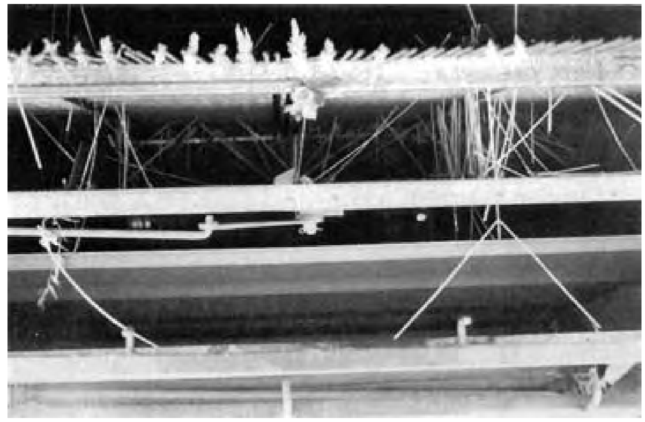

FIGURE 14. Shoe Spearing.

Header Adjustment: The CI 9600 was tested only with a pickup attachment for windrowed crops. The header platform could be removed by one person in about 30 minutes while complete removal of the header and feeder house assembly took two people about 45 minutes.

The table auger was easy to adjust vertically and horizontally. Minimum table auger clearance was too great for light crops. It is recommended that the manufacturer consider increasing the range of adjustment for table auger clearance to make smaller clearances possible in light crops.

Slip Clutches: Individual slip clutches protected the power take-off drive line, table auger and feeder conveyor. The table auger and feeder conveyor clutches were easily adjusted to suit working conditions.

RATE OF WORK

Average Workrates: TABLE 3 presents average workrates for the CI 9600 in all the crops harvested during the test. As average workrates are affected by crop conditions, windrow quality, field conditions and availability of grain handling equipment, they should not be used to compare combines tested in different years. Average workrates varied from 4.9 t/h (225 bu/h) in 3.1 t/ha (58 bu/ac) Hector barley to 2 t/h (77 bu/h) in 1.3 t/ha (20 bu/ac) Cougar fall rye.

TABLE 3. Average Workrates.

Crop	Variety	Average Yield t/ha	Average Speed km/h	Average Workrate	
				ha/h	t/h
Barley	Betzes	2.6	3.5	1.7	4.4
Barley	Fergus	2.4	3.2	1.8	4.3
Barley	Hector	3.1	3.4	1.6	4.9
Barley	Klages	2.5	3.5	1.9	4.8
Barley	Melvin	2.4	3.8	1.8	4.3
Fall Rye	Cougar	1.3	4.5	1.6	2.0
Fall Rye	Puma	1.1	4.5	2.2	2.4
Flax	Dufferin	1.8	4.0	1.6	2.9
Rapeseed	Candle	1.6	3.2	1.4	2.2
Rapeseed	Torch	1.1	4.7	2.3	2.6
Wheat	Neepawa	3.0	2.6	1.6	4.8

Maximum Feedrate: The workrates given in TABLE 3 represent average workrates at acceptable loss levels. The tractor used for this test had ample power to achieve much higher workrates in all crops. In most crops, the maximum acceptable feedrate was limited by grain loss, while in light crops, the maximum feedrate was limited by pickup performance. In heavy bunchy crops, the feedrate was limited by cylinder and table auger plugging.

Capacity: Combine capacity is the maximum rate at which a combine, adjusted for optimum performance, can harvest a crop at a specified 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 cause capacity variations.

MOG Feedrate, MOG/G Ratio, and Percent Loss: When determining combine capacity, combine performance and crop

TABLE 4. Capacity at a Total Loss of 3% of Yield

Crop Conditions							Capacity Results			
				Grain Moisture						
Crop	Variety	Width of Cut m	Crop Yield t/ha	Straw %	Grain %	MOG/G	MOG Feedrate t/h	Grain Feedrate t/h	Ground Speed km/h	Loss Curve
Canola	Candle-	6.4	1.61	11.3	7.7	1.91	5.0	2.6	2.5	Fig. 15
Wheat	Neepawa	6.1	2.95	5.6	11.4	0.98	10.5	10.7	5.9	Fig. 16
Barley	Klages	6.4	2.75	7.4	11.4	0.74	6.0	8.1	4.6	Fig. 17

conditions must be expressed in a meaningful way. The loss characteristics of a combine in a certain crop depend mainly on two factors, the quantity of grain being processed. The mass of straw and chaff passing through a combine per unit time is called MOG Feedrate. MOG is an 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 time is called Grain Feedrate. The ratio of the MOG Feedrate to the Grain Feedrate, which is abbreviated as MOG/G, gives an indication of how difficult a crop is to separate. For example, if a combine is used in two wheat fields of identical yield, but one with long straw and one with short straw, the combine will have better separation ability in the short crop and will be able to operate faster. This crop variable is expressed as the MOG/G ratio. MOG/G ratios for prairie wheat crops vary from about 0.5 to 1.5.

Grain losses from a combine are of two main types, unthreshed grain still in the head and threshed grain or seed, 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 loss and walker loss. Losses are expressed as a percent of 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 CI 9600: TABLE 4 presents capacity results for the CI 9600 in three different crops. MOG Feedrates for a 3% total grain loss varied from 10.5 t/h (386 lb/min) in a field of 2.95 t/ha (44 bu/ac) Neepawa wheat to 5.0 t/h (184 lb/min) in 1.61 t/ha (29 bu/ac) Candle canola.

GRAIN LOSS CHARACTERISTICS

The grain loss characteristics for the CI 9600 in the three crops described in TABLE 4 are presented in FIGURES 15 to 17.

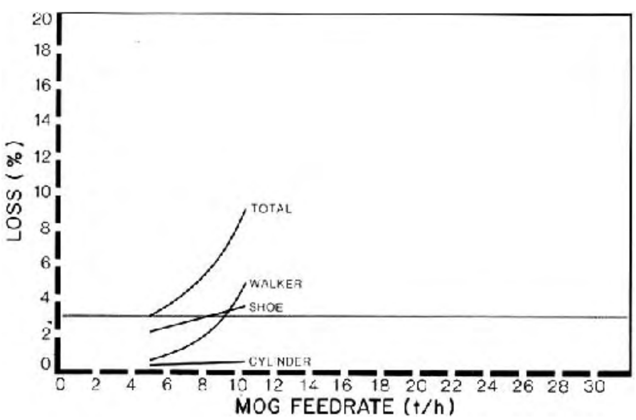

FIGURE 15. Grain Loss in Candle Canola.

Walker Loss: While walker loss was the most significant factor affecting capacity in barley, walker and shoe losses were nearly balanced in dry wheat. Common to most conventional combines, walker loss was lower than shoe loss in canola and rapeseed. Shoe Loss: Shoe loss did not limit combine capacity in grain crops. In rapeseed and flax, optional fan doors had to be used as the minimum fan speed was not slow enough to prevent airborne seed loss.

Cylinder Loss and Grain Damage: Cylinder loss was low in most crops. In Klages barley when cylinder losses were negligible (FIGURE 17), grain cracks were about 1.5% (FIGURE 18). In Neepawa wheat, a more difficult-to-thresh crop, cylinder and concave adjustments were important and final settings reflected a compromise between cylinder loss and grain damage. For example, while cylinder loss in Neepawa wheat was very low (FIGURE 16), grain cracks were about 5% (FIGURE 18). In Candle canola, cylinder loss (FIGURE 15) and grain cracks (FIGURE 18) both were very low.

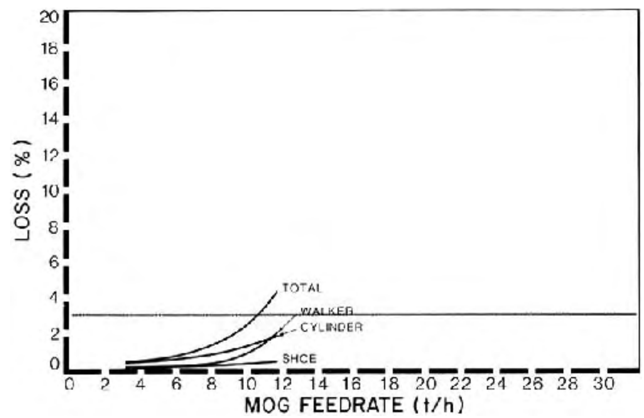

FIGURE 16. Grain Loss in Neepawa Wheat.

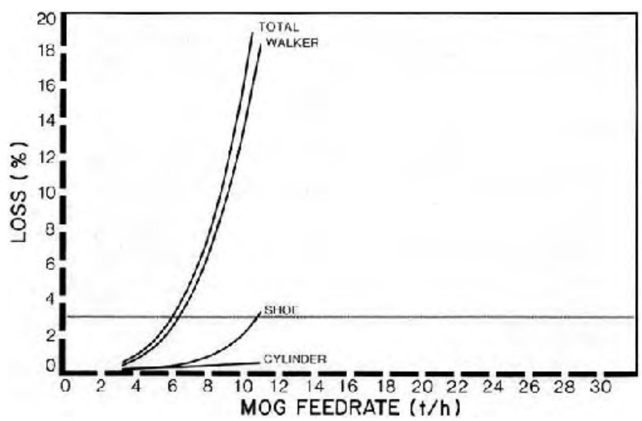

FIGURE 17. Grain Loss in Klages Barley.

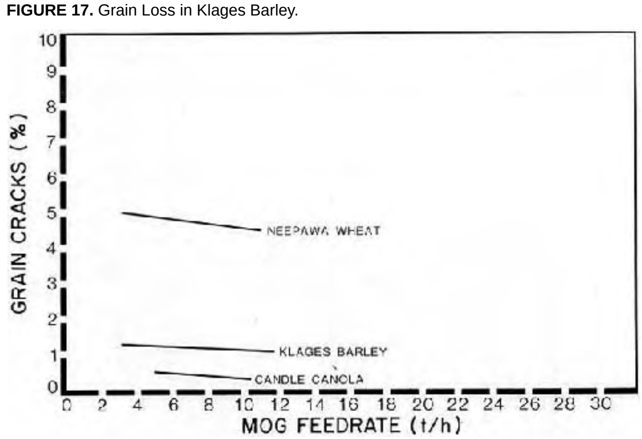

FIGURE 18. Grain Damage.

Body Loss: Leakage of grain from the combine body was negligible in grain crops. In flax and rapeseed, some losses occurred at the header junction, around the shoe housing and from the elevator doors. Losses were very low and most were eliminated by adding suitable packing material.

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, PAMI uses a reference combine. This combine is operated alongside test combines whenever capacity measurements are made. This permits the comparison of loss characteristics of every test combine to those of the reference combine used by PAMI is commonly accepted in the prairie provinces and is described in PAMI evaluation report E0576C. See APPENDIX III for PAMI reference capacity results.

FIGURES 19 to 21 compare the total grain losses of the CI 9600 and the PAMI reference combine in the crops described in TABLE 4. The shaded areas on the figures are the 95% confidence belts. If the shaded areas (confidence belts) overlap, loss characteristics of the two combines are not significantly different whereas if the shaded areas do not overlap, the losses are significantly different. The capacity of the CI 9600 was similar to the capacity of the reference combine and the CI 9600 had grain losses similar to those of the reference combine when operating at the same feedrate.

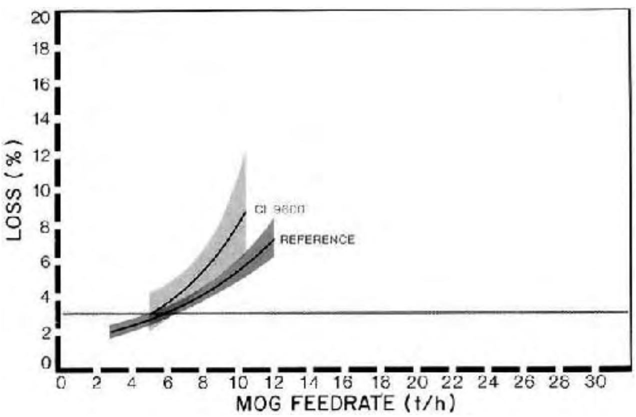

FIGURE 19. Total Grain Loss in Candle Canola.

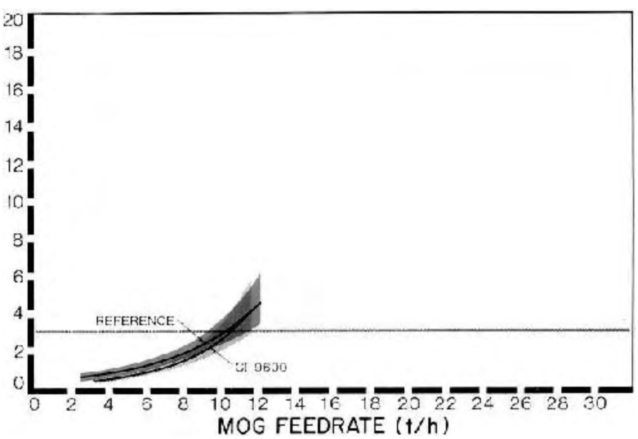

FIGURE 20. Total Grain Loss in Neepawa Wheat.

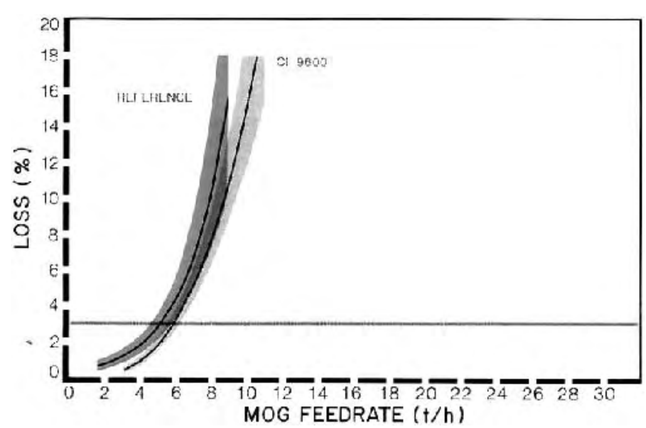

FIGURE 21. Total Grain Loss in Klages Barley.

GRAIN LOSS MONITOR ACCURACY

The CI 9600 grain loss monitor indicated the presence of grain loss, but did not accurately indicate actual loss rate, as is common with most grain loss monitors. When calibrated for a 3% total grain loss level, the monitor read high at low to moderate feedrates, and read low at high feedrates.

POWER REQUIREMENTS

Power Consumption: The manufacturer recommends a 90 kW (120 hp) tractor.

Power consumption was measured in wheat and barley. When operating at a 3% total grain loss, power input was 31 kW (42 hp) in wheat and 22 kW (30 hp) in barley (FIGURE 22).

OPERATOR SAFETY

The CI 9600 was adequately equipped with warning decals for all dangerous areas such as the straw chopper, grain tank, power take-off and machine drives.

The CI 9600 had adequate warning lights and a slow moving vehicle sign for road transport.

The shielding provided good protection from moving parts. The shields were easy to remove and install, or swung away to permit easy access.

The CI 9600 was equipped with a header lock, which was pinned to prevent accidental disengagement.

A hitch safety chain was supplied as standard equipment.

The drawpole jack was safe, convenient and easy to use. This jack could be placed at the rear of the combine to prevent tipping rearward when the header was removed. A fire extinguisher (class ABC) should be carried on the combine or tractor at all times.

OPERATOR'S MANUAL

The operator's manual was clearly written and adequately illustrated. It contained useful information on safe operation, adjustments, settings, service and lubrication. A very useful section was included on belt removal and replacement procedure.

The two sections on windboard adjustment should be deleted as the CI 9600 no longer has a windboard.

DURABILITY RESULTS

TABLE 5 outlines the mechanical history of the Co-op Implements 9600 during 170 hours of operation while harvesting about 305 ha (754 ac). The intent of the test was evaluation of functional performance. An extended durability evaluation was not conducted.

TABLE 5. Mechanical History

Item	Operating Hours	Field Area ha
Power Shaft		
-The power take-off shaft wood support blocks loosened and were tightened	throughout the test	
Drives		
- The idler spring on the clean grain elevator drive was lost and replaced at	8	14
Miscellaneous		
-The original straw chopper, which vibrated excessively when operating, was replaced with another chopper at	beginning of test	
-The electromagnetic header clutch became inoperative and was repaired at 10 18 -The straw chopper warning light malfunctioned and was repaired at	23	42
-The header lift hydraulic hose burst and was repaired at	53	105
-The inboard bearing on the pickup jackshaft failed and was replaced at	57	103
-The grain tank levelling auger drive chain tightening block wore excessively and was replaced at	59	108
-The wires on the electric header clutch sheared and were repaired at	63	120

DISCUSSION OF MECHANICAL PROBLEMS

Grain Tank: The grain tank levelling auger drive chain tensioning block wore excessively. It is recommended that the manufacturer consider modifications to reduce tension block wear.

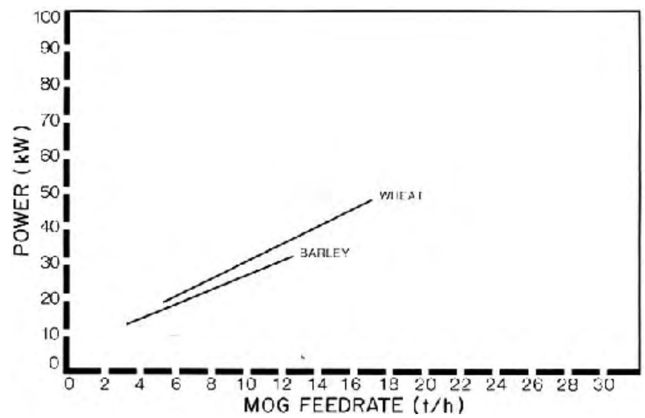

FIGURE 22. Power Take-Off Input,

APPENDIX I

MAKE:	Co-op Implements
MODEL:	9600 Pull-Type Combine
SERIAL NUMBER:	20930
MANUFACTURER:	Canadian Co-operative Implements Limited 770 Pandora Avenue East Winnipeg, Manitoba R2C 3N1
WINDROW PICKUP:	
-- make and model	Melroe 378
-- type	rubber draper with rubber transfer draper
-- pickup width	3215 mm
-- number of belts	7
-- teeth per belt	70
-- type of teeth	spring steel
-- number of rollers	4
-- height control	castor wheels
-- speed control	electrically controlled variable pitch belt
-- speed range	0.8 to 1.3 m/sec
HEADER:	
-- type	off-set
-- width	3230
-- auger diameter	505
-- feeder conveyor	3 roller chains, undershot slatted conveyor
-- conveyor speed	2.23 m/sec
-- range of height	65 to 1020 mm
-- number of lift cylinders	1
FEEDER BEATER:	
-- type	four blade integral
-- diameter	153 mm
-- speed	675 to 1310 rpm
CYLINDER:	
-- type	rasp bar
-- number of bars	8
-- diameter	605 mm
-- width	1100 mm
-- drive	electrically controlled variable pitch belt
-- speed range	580 to 1130 rpm
CYLINDER BEATER:	
-- type	4 blade box
-- diameter	375 mm
-- speed	675 to 1310 rpm
CONCAVE:	
-- type	bar and wire
-- number of bars	14
-- configuration	13 intervals with 6.2 mm wires and 8.25 mm spaces
-- area total	0.660 m²
-- area open	0.332 m²
-- transition grate area total	0.163 m²
-- transition grate area open	0.122 m²
-- wrap	115 degrees
-- grain delivery to shoe	grain pan
STRAW WALKERS:	
-- type	rotary, formed metal
-- number	4
-- length	3160 mm
-- walker housing width	1100 mm
-- separating area	3.476 m²
-- crank throw	100 mm
-- speed	230 rpm
-- grain delivery to shoe	closed bottom walkers
SHOE:	
-- type	single action
-- speed	325 rpm
-- chaffer sieve	adjustable lip, 1.338 m² with 39 mm throw
-- chaffer extension	stationary wires, 0.120 m²
-- clean grain sieve	adjustable lip, 1.198 m² with 39 mm throw
CLEANING FAN:	
-- type	4 blade undershot
-- diameter	610
-- width	1000 mm
-- drive	crank controlled variable pitch belt
-- speed range	470 rpm to 800 rpm
-- options	adjustable fan doors
ELEVATORS:	
-- type	roller chains with rubber flights, top delivery
-- clean grain (top driven)	125 mm x 230 mm
-- tailings (top driven)	125 mm x 230 mm
GRAIN TANK:	
-- capacity	5.1 m³
-- unloading time	109 s
STRAW CHOPPER:	
-- type	rotor with 24 freely swinging hammers and 23 stationary knives
-- speed	3000 rpm
CLUTCHES:	
-- header	electro-magnetic
-- unloading auger	electro-magnetic
NUMBER OF CHAIN DRIVES:	5
NUMBER OF BELT DRIVES:	12
NUMBER OF GEARBOXES:	1
NUMBER OF PRELUBRICATED BEARINGS:	62
LUBRICATION POINTS:	
-- 10 h lubrication	3
-- 50 h lubrication	19
TIRES:	
-- right	18.4 x 26, 10-ply
-- left	18.4 x 26, 10-ply
OVERALL DIMENSIONS:	
-- wheel tread	2640 mm
-- transport height	3480 mm
-- transport length	10350 mm
-- transport width	4490 mm
-- field height	3480 mm
-- field length	10420 mm
-- field width	7420 mm
-- unloader discharge height	3020 mm
-- unloader clearance height	2750 mm
-- unloader reach	2300 mm
WEIGHT: (with empty grain tank and hitch in field position)	
-- right wheel	2470 kg
-- left wheel	1960 kg
-- hitch	380 kg
TOTAL	4810 kg

APPENDIX II
REGRESSION EQUATIONS FOR CAPACITY RESULTS

Regression equations for the capacity results shown in FIGURES 15 to 17 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 15 to 17 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
Canola - Candle	15	C = 0.12 + 0.04F S = 0.81 + 0.27F lnW = -2.53+0.40F	0.90 0.67 0.93	29.52[2] 5.72[1] 46.30[2]	9
Wheat - Neepawa	16	lnC = -1.89 + 0.22F lnS = -3.51 + 0.23 lnW = -5.11 + 0.50F	0.97 0.98 0.98	91.27[2] 128.97[2] 127.78[2]	8
Barley - Klages	17	C = -0.8 - 0.05F lnS = -4.01 + 0.48F lnW = -4.91 + 3.27 lnF	0.82 0.99 0.99	12.17[2] 285.55[2] 301.65[2]	8

[1]Significant at $P \leq 0.05$
[2]Significant at $P \leq 0.01$

APPENDIX III
PAMI REFERENCE COMBINE CAPACITY RESULTS

TABLE 7 and FIGURES 23 and 24 present the capacity results for the PAMI reference combine m wheat and barley crops harvested from 1976 to 1980.

FIGURE 23 shows capacity differences in Neepawa wheat for the five years. Most 1980 Neepawa wheat crops shown in TABLE 7 were of average straw yield and better than average gram yield. Most of the crops were average to thresh while the grain moisture was slightly lower than the other years and the straw moisture content was average to lower than normal.

FIGURE 24 shows capacity differences in six row Bonanza barley for 1976 to 1978, two row Fergus barley for 1979 and two row Hector barley for 1980. The 1980 Hector barley crops shown in TABLE 7 were of average straw yield, easy-to-thresh and average straw and grain moisture content.

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 7. Capacity of the PAMI Reference Combine at a Total Grain Loss of 3% of Yield

	Crop Conditions							Capacity Results			
					Grain Moisture			MOG Feedrate	Grain Feedrate	Ground Speed	
Year	Crop	Variety	Width of Cut m	Crop Yield t/ha	Straw %	Grain %	MOG/G	t/h	t/h	km/h	Loss Curve
1980	Barley	Hector	6.1	3.48	13.8	14.5	0.69	5.5	8.0	3.8	Fig. 24
	Barley	Hector	6.1	3.16	13.4	14.4	0.68	5.8	8.5	4.4	
	Barley	Klages	6.4	2.75	5.7	11.1	0.63	5.6	6.9	5.0	
	Canola	Candle	6.4	1.67	9.9	8.7	1.72	5.7	3.3	3.1	
	Wheat	Neepawa	12.2	2.87	7.2	13.2	0.88	9.4	10.6	3.0	
	Wheat	Neepawa	6.1	3.12	6.0	11.4	0.98	10.1	10.3	5.4	Fig. 23
	Wheat	Neepawa	12.2	3.09	3.2	12.2	1.02	10.2	10.0	2.7	
	Wheat	Neepawa	6.1	3.00	4.9	10.8	0.91	10.3	11.3	6.2	
1979	Barley	Klages	6.1	3.67	dry	11.7	0.64	6.8	10.6	4.7	
	Wheat	Neepawa	7.3	2.77	dry	14.1	1.21	9.5	7.8	3.9	
	Wheat	Neepawa	6.1	2.67	dry	14.3	1.09	9.7	8.9	5.4	Fig. 23
	Barley	Fergus	7.3	3.46	dry	12.5	0.77	7.3	9.5	3.7	Fig. 24
1978	Wheat	Canuck	7.3	2.54	7.1	12.1	1.15	11.8	10.3	5.6	
	Wheat	Lemhi[1]	11.0	2.13	6.6	12.0	0.75	10.9	14.5	6.2	
	Wheat	Neepawa	6.1	4.37	10.4	15.9	1.04	9.3	8.9	4.5	Fig. 23
	Barley	Bonanza	6.1	4.06	7.7	13.5	0.68	6.1	9.0	3.6	Fig. 24
1977	Wheat	Neepawa	6.1	3.97	13.4	14.6	0.79	11.1	14.1	5.8	Fig. 23
	Barley	Bonanza	7.3	4.74	25.7	14.6	0.84	7.9	9.4	2.7	Fig 24
1976	Wheat	Neepawa	5.5	2.78	dry to tough	14.7	1.29	7.1	5.5	3.6	Fig. 23
	Barley	Bonanza	7.3	3.18	dry to tough	14.6	0.96	4.8	5.0	2.2	Fig 24

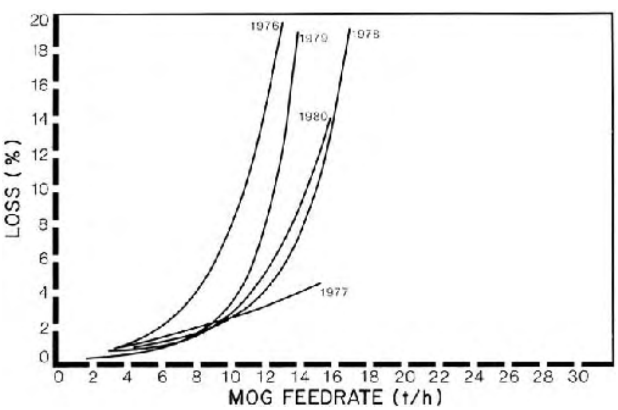

FIGURE 23. Total Grain Loss for the PAMI Reference Combine in Neepawa Wheat.

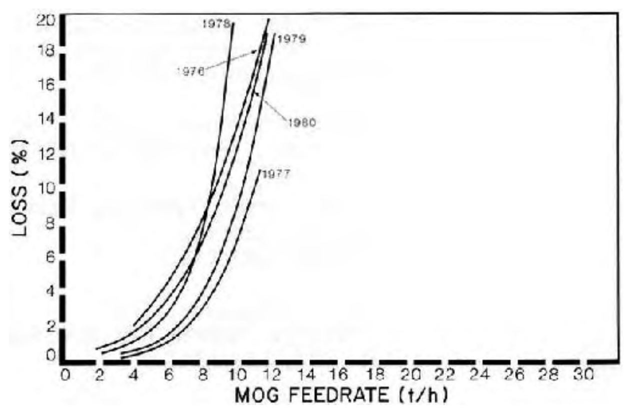

FIGURE 24. Total Grain Loss for the PAMI Reference Combine in Barley.

APPENDIX IV
MACHINE RATINGS

The following rating scale is used in PAMI Evaluation Reports:

(a) excellent	(d) fair
(b) very good	(e) poor
(c) good	(f) unsatisfactory

APPENDIX V
CONVERSION TABLE

1 kilometre/hour (km/h)	= 0.6 miles/hour (mph)
1 hectare (ha)	= 2.5 acres (ac)
1 kilogram (kg)	= 2.2 pounds mass (lb)
1 tonne (t)	= 2200 pounds mass (lb)
1 tonne/hectare (t/ha)	= 0.5 ton/acre (ton/ac)
1 tonne/hour (t/h)	= 37 pounds/minute (lb/min)
1 kilowatt (kW)	= 1.3 horsepower (hp)
1 litre/hour (L/h)	= 0.2 Imperial gallons/hour (gal/h)
1 metre (m)	= 3.3 feet (ft)
1 millimetre (mm)	= 0.04 inches (in)

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